Great Sand Dunes National Monument and Preserve
Coliform Risk Analysis

Provided For:
National Park Service
Public Health Program

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List of Acronyms

CDPHE	Colorado Department of Public Health and the Environment
Cfu	Colony Forming Units
CMC NRMI	Colorado Mountain College Natural Resource Management Institute
E. Coli	*Escherichia coli*
GRSA	Great Sand Dunes National Park
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MPN	Most Probably Number
NPS	National Park Service
NPS PHP	National Park Service Public Health Program
SOW	Scope of Work
USGS	United States Geological Survey
WRD	NPS Water Resources Division
WRMP	Water Resource Management Plan

EXECUTIVE SUMMARY

The following document provides a DRAFT summary Risk Analysis of Coliform exposure and effects to human health within the Great Sand Dunes National Park. This Risk Analysis was developed by compiling historic and current Coliform sampling data obtained from the Medano Creek watershed system in order to characterize the source, fate and transport of Coliform (termed source characterization). An in-field survey of recreator contact with Medano was completed in order to characterize exposure conditions (exposure assessment). Thus, the source characterization information was combined with the exposure assessment in order to derive the conclusions presented in the risk analysis. These two components were combined in order to obtain a realistic determination of risk to human health.

It has often been determined that while detrimental levels or concentrations of a given contaminant may be present in the environment, the actual amount or rate of exposure is minimal, therefore receptors (i.e. human health) are not subject to the deleterious effects. Such appears to be the case for the Great Sand Dunes National Park. While observations of Coliform presence within the park have been noted for years the actual risk to human health appears minimal for the following reasons:

1. Measured concentrations are representative of 'Total Coliform of Fecal Coliform'. Total Coliform and Fecal Coliform are not necessarily toxic or 'pathogenic'. Instead they are an indicator of the potential presence of pathogenic organisms which can cause illness, such as *Escherichia coli*. The use of the presence of Total Coliform and Fecal Coliform for this analysis, was therefore over conservative of the actual conditions of pathogen occurrence.

2. The amount of actual recreator exposure is minimal. Measured contact times were recorded during weekend and weekdays and determined to be on average: acute dermal contact with an exposure period of less than 5 minutes for adults, acute dermal contact with an exposure period of less than 5 minutes for children (less than 17 years of age). There are notable exceptions to these averages however. Numerous children were observed to directly ingest water and sediment materials from the creek system. Several were observed to recreate in the creek for periods of hours, and repeated days.

Existing (historic and current) data obtained from sampling events taken place within the park, were compiled and evaluated. This information was evaluated to identify trends in regards to Coliform occurrence, fate and transport. Summary observations describing the nature and extent of Coliform occurrence within the park are as follows;

- The occurrence of Coliform within the Medano creek system appears to follow trends related to flow (Coliform concentrations dilute with increased flow), and are prevalent at areas of high recreator use.

- There are numerous sources to the creek system inclusive of the children that recreate in the stream, pets and horses (from the park as well as a trail-ride vendor).

- Backcountry areas have notable occurrence of Coliform that may be related to wildlife sources (beaver, horses, pets) and the back-country campers that use the area.

- Years of sampling and analysis have been completed within the park (since 1989 to present). At least three distinct methods of collection/analysis have been

used in relation to the state of the science in regards to testing. This however, limits the ability to compare all data sets together.

The information describing the nature and extent of Coliform occurrence was coupled with gathered information regarding recreator exposure conditions in order to determine the risk. A field effort was completed in order to document recreator characteristics and rates of exposure to possible Coliform contaminated areas within Medano. A summary of the exposure observations is as follows;

- The average adult male and female recreator is exposed via dermal contact for a rate of less than 5 minutes. These people cross Medano to access the Dunes for hiking purposes.

- The average child (male and female) is exposed via dermal and ingestion for more prolonged periods. Dermal contact rates occur on an average of 2-3 minutes. Ingestion occurs incidentally.

- Elderly recreators represent the category of receptor with the least amount of exposure. Typically these people rarely come in contact with Medano creek.

- The exposure pathway of concern in regards to Coliform is ingestion. As such, the only receptor category of concern would be children since adults tend to limit exposure to dermal contact, the exception being back-country hikers using Medano waters directly (without use of a filter).

Results of the risk analysis indicates:

1 The area with the highest observed concentrations of Coliform is collocated with the area of highest recreator contact and exposure. This poses two points: 1) it is possible that the recreators themselves are a component of the source, and 2) there is the potential for complete exposure and possible effects.

2 There are numerous sources (animal and human) as demonstrated by the nature and extent of Coliform occurrence. Backcountry areas show some of the highest concentrations, yet have the lowest rate of recreator contact. This indicates 'animal' sources are present.

3 It appears that Coliform occurrence is also related to flow within the Creek. Dilutional flows created by Spring snow-melt afford some level of protection by masking Coliform occurrence. This time period coincides with some of the highest rates of visitor occurrence, thus providing a protection against exposure.

3 The observed concentrations of Coliforms do exceed thresholds for the protection of human health in a minimal number of cases. The nature and extent of exceedences is discussed for each study in subsection 4.3. In summary of all these studies, the number of exceedences is rare overall, the general water quality is good and falls within criteria limit.

4 There is uncertainty with the ability of the NPS to track human health concerns due to the incompatibility of the method currently used which provides results in units of MPN. These values can not be directly compared to human health thresholds.

5 Times of year that are of concern would include holidays and weekends during the

summer which correlate to high visitor activity and low flows. Areas or sites of concern are associated with the 'boardwalk' which is the highest use area, and contains some of the highest observed levels of Coliform.

6 Exposure, fortunately is very limited and occurs via dermal contact which is not a tremendous issue in regards to Coliform. As demonstrated in this study, the majority of visitors only incidentally become exposed. Concern however does arise from the fact that children do incidentally ingest water, and a complete exposure pathway does exist. It is this pathway that needs to be controlled if Coliform levels continue to rise (refer to recommendations).

Recommendations that result from the findings of this study include;

1) conduct further evaluation of Coliform occurrence to identify key source areas as well as seasonal and recreator impacts to the observed levels, and
2) instigate a possible education outreach to the visitors to assist with limiting possible sources and exposure pathways.

Photo 1. Medano Creek as seen from the Boardwalk.

1 Introduction

This effort represents a DRAFT Risk Analysis of the possible Coliform exposure and effects to human health within the Great Sand Dunes National Park. This effort was completed as part of an internship agreement between Colorado Mountain College Natural Resource Management Institute (CMC NRMI) and the National Park Service – Public Health Program (NPS PHP). This information is DRAFT and subject to review and comment.

The NPS – PHP first identified a possible concern associated with Coliform within Medano Creek, from historic data indicating a consistent presence throughout the park. Further preliminary research indicated that the Coliform concentrations appear to be related to flow (higher flow, more dilution), and rate of visitor contact. The NPS PHP requested that all available information characterizing the nature and extent of Coliform occurrence be completed, and to determine if there is a possible human health issue associated with the Coliform.

1.1 Purpose and Goals

The Purpose of this effort was to compile existing information that characterizes the nature and extent of Coliform within the Medano creek portion of the Great Sand Dunes National Park (the Park), and determine if the observed levels are correlative to possible human health effects. The PHP has directed CMC NRMI to gather available information and determine if sufficient information exists in order to determine human health effects. In the absence of sufficient information, a gap analysis would be documented.

'Effects' are synonymous with deleterious condition or toxicity. Toxicity of any contaminant is related to the exposure conditions associated with the human receptors. Therefore, in order to define the human health effects, the following goals needed to be addressed:

1) to determine the nature and extent, as well as possible source areas of the Coliform within Medano Creek,

2) to determine the receptor populations associated with Coliform exposure (within Medano Creek)

A Scope of Work (SOW) for the CMC NRMI Interns that would complete this work was documented and reviewed by the NPS PHS (CMC NRMI, 2004). Within the SOW, three tasks were delineated which would serve to compile existing information (Task 1), identify data gaps (Task 2), then address as many data gaps where possible during field efforts (Task 3) and document all methods and findings from these three tasks. A summary of the tasks within the SOW are described as follows;

Task 1 – Background Research. Conduct research to gather and compile all existing information available that characterizes the issue (i.e. any data already gathered from sample analysis, or information characterizing the site setting, nature and extent of the contamination, possible source areas etc.).

Task 2 – Gap Analysis. Complete a 'data gap analysis' and complete, where needed, in-field studies in order to fill these data gaps. In some cases, there may not be sufficient information from which to characterize the problem. Samples may need to be gathered for analysis, and on-site surveys to determine exposure conditions are likely to be needed in all cases. The CMC NRMI Field Manager (Lisa Miller) will be responsible for conducting site visits to obtain the data needed to fill the identified gaps.

Task 3 – Risk Analysis and Documentation. All the gathered information from Tasks 1 and 2 will be compiled to characterize the issue. The results of the data will be coupled with the exposure information to determine the potential risk to exposed populations (for the Great Sand Dunes an evaluation of potential risk based upon site conditions of contaminant occurrence and potential to migrate). These projects will explore the 'science of the issue' by conducting research that describes the problem, the possible effects and concerns (i.e. lead exposure effects to human receptors) using methods that will look beyond typical exposure assessment methods (i.e. MCL comparisons) to try to bring to reality the risk and current effects conditions within the park setting. The methods and results of each project will be documented into a Technical Memorandum (TM). An independent TM will be written for each project. The CMC NRMI program administrator will assist with document production and review. A DRAFT set of TMs will be provided to the NPS PHP.

Task 4 – Review and Comment. The NPS PHP will review and comment on each TM provided. Based upon the comments etc., CMC NRMI will revise and produce FINAL versions. These documents may in-turn be published through applicable Journals such as: Park Service Science or the Journal of Environmental Health.

1.2 Methods

There are two components to the Methods used for this analysis, 1) background research to compile existing data and information that describes the issue, and 2) an in-field effort to gather real-time information for the presence/absence of Coliform within the park, and the exposure conditions for the visitors. The following describes the distinct methods to each component:

Background Research

Background research was completed by accessing documents and databases that contain information about the nature and extent of Coliform within the park. The NPS archival library (Fort Collins, Colorado) was relied upon for access to unique records, not necessarily available on-line or elsewhere (copies of literature citations provided in **Appendix C**). Additional documents were obtained directly from the Park. The point of contact for the NPS library was: Laura Harte/NPS Librarian. As a result of reviewing all available documents, there were four key sources of existing information that were relied upon for this report:

1) the National Park Service compiles 'baseline' reports for each park which summarizes water quality within and around the park from existing federal and state water quality databases such as STORET, WATSTORE and others,
2) the 1997 NPS 'Water Resources Management Plan' for the park (NPS, 1997),
3) the USGS and the NPS completed a study of water quality from within the park from 1999 through 2000 and documented the results of organic, inorganic and biological constituent occurrence (Ferguson, 2003), and
3) available data sets obtained directly from the park (source: Fred Bunch/NPS: copies provided in **Appendix A**). The following summarizes the information obtained from each of these three key sources.

A summary description of the information obtained from each of these sources is described in the following:

1) **NPS – Baseline Report (NPS, 1998)**. A baseline report (NPS, 1998) was written for the Park. Data from (1965 to (2004) was compiled for locations within and outside the park. Review of the document identified the following:

1 The document provides a summary of results of surface water quality data retrievals from six of the United States Environmental Protection Agency's national databases (1) Storage and Retrieval (STORET), (2) River Reach File, (3) Industrial Facilities Discharge (IFD), (4) Drinking Water Supplies (DRINKS), (5) Water Gages (GAGES), and (6) Water Impoundments (DAMS).

2 The document provides a complete inventory of all retrieved water quality parameter data, water quality stations and the entities responsible for the data collection, descriptive statistics, a comparison of the water quality data to relevant EPA and WRD water quality screening criteria, and an inventory data evaluation and analysis to determine what Service-wide Inventory and Monitoring program water quality parameters have been measured.

3 Most of the monitoring stations represent either one-time or intensive single-year sampling efforts by the collecting agencies. One station within the park boundary, Medano Creek near Mosca (GRSA 0047), yielded a longer-term record consisting of multiple observations for several water quality parameters.

4 It was observed that Fecal-indicator bacterial concentrations (Fecal Coliform) exceeded the WRD screening limits for freshwater bathing.

5 Ten locations were identified in the park for use in this report. All ten locations were within park boundary (**Figure 2**).

6 For the purposes of this project, Fecal-indicator bacteria data were flagged as exceeding criteria when their concentrations exceeded 200, 1000, 126, and 33 colony forming units or most probably number for single samples of Fecal Coliform, Total Coliform, *E. coli* and *Enterococci*, respectively. These values represent only approximations of the criteria for primary contact recreation waters where criteria ate typically expressed in terms of a geometric mean computed with no less than 5 samples during a given month.

2). **NPS – Water Resources Management Plan (NPS, 1997).** Water Resources Management Plans (WRMPs) are prepared in NPS units where the water resource issues are particularly important, complex or controversial (NPS, 1997). The park completed this plan in 1997 in order to describe key issues associated with water resources within and surrounding the park. Their efforts included water quality sampling and analysis for Coliforms.

3). **USGS – Investigation of Water Quality in the Great Sand Dunes National Monument and Preserve, Saguache County, Colorado, February 1999 through September 2000: Qualifying for Outstanding Waters Designation.** (Ferguson, 2003). The USGS in cooperation with the NPS investigated the water quality at 15 sites within the park boundaries from 1999 through 2000.

4). **Available data sets obtained from the Park (Appendix A).** Fred Bunch/NPS Provided data sets from field events taken place over (years). In addition, a field sampling event was coordinated between NPS and CMC NRMI during the field event. All data relied upon from these supplemental studies are copied and provided in **Appendix A.** There were two distinct methods followed for the sampling, based upon applicable and available methodologies at the time.

1 The first data set, gathered from 1995 through 1998 were evaluated by NPS (1995) and SLV Analytical (1998), results are expressed in units of # fecal coliform per ml for 1995, and # fecal coliform per 100 ml for 1998. The sampling results for efforts completed from 1995 through 1998 are presented in **Figure 3**, for sampling completed in 1998 through 2004 in **Figure 4** and the locations for these efforts are depicted on **Figure 5.**

2 The second data set, gathered from 2002 through 2004 was gathered and analyzed by the NPS. Results for 2002 are expressed as Most Probably Numbers (MPN). The method used for sample collection, analysis and results was provided by the NPS (a copy is provided in **Appendix A**) The sampling locations for these efforts are different from those studied in 1995-1998, and are depicted on **Figure 5.**

Field Effort

There were several objectives to the field effort completed for this study. These objectives included 1) coordination of this analysis with the park personnel to gain an understanding of its purpose and intent (discussions with Fred Bunch – park Naturalist, and Steve Chaney – park Superintendent), 2) to gather any park records that would enhance the database or provide more information about the nature and extent of the Coliform occurrence in the park, 3) to conduct an in-field sampling event to characterize Coliform within the Medano creek portion of the park, and 3) to gather observational data to determine exposure conditions for visitors to the park.

On June 4, 2004; CMC NRMI met with Fred Bunch and Steve Chaney to discuss the purpose of this effort. It was communicated that this effort is an iterative 'work in progress' for the park to provide review and guidance. Several key points regarding Coliform issues were brought to light including the possible sources of pets and horses which frequent the park. It was also coordinated with the park personnel for CMC NRMI to be present within the Entrance Station over the course of a weekend as well as portions of weekdays in order to gather data about visitors entering the park (numbers of adults, children, pets, and point of origin), and also be a part of the planned Coliform sampling to take place the following week. Park personnel also provided additional data and records of use to this evaluation. The additional data provided by the NPS from more current sampling events is provided in **Appendix A**, while copies of meeting notes and correspondence are provided in **Appendix C.**

The evaluation of ongoing exposure conditions within the park was a key component to the field effort. It was decided necessary to collect onsite observational data documenting the characteristics of the types of recreator activity, routes and rates of exposure, since the toxicity of Coliform is dependent upon these factors. Before the June field effort, research was conducted to determine the location of the Coliform hazards. The research included gathering information from the National Forest Library in Fort Collins, searching web pages such as the ATSDR, EPA, Toxicology reports, USGS, and gathering information from the Baseline study completed in 1998 (NPS, 1998). On June 5, 6, 10, 11, 12, and 13 from 9:00 AM to 4:30 pm observations of recreator activity associated with Medano creek was completed at the Boardwalk Crossing, since it was determined that this location held the highest possibility of a complete exposure pathway. This location is the walkway from the visitor's center to Medano Creek.

The information collected for each recreator observed included; age, sex, body weight, activity with water, duration of exposure and type of exposure (dermal contact and/or ingestion). Lisa Miller/CMC NRMI remained at the park from June 5 through June 13, 2004 and completed this portion of the effort, in addition to completion of a sampling event for the determination of Coliform presence within the watershed. A summary of the completed tasks during the field effort is as follows

1 Sampling of *E. Coli* and Coliform on June 8, 2004 from 14:25 to 17:30 and on June 9 from 8:35 to 11:45 was conducted with Katie Hagaman with the NPS.

2 Site observations of visitor exposure conditions was conducted on:
   - June 5 from 9:30 to 16:10 and June 6 from 9:30 to 15:30 observations were conducted at the Boardwalk Crossing near the Visitors Center.
   - June 7th from 9:45 to 17:00 observations were conducted at the Entrance Booth.
   - June 9th from 14:10-17:00 observations at the Entrance Booth.
   - June 10 from 8:50 to 13:45 observations were conducted at the Boardwalk Crossing near the Visitors Center.
   - June 11 from 9:20 to 16:30, June 12 from 9:30 to 16:30 and June 13 from 9:00 to 12:00 observations were conducted at the Boardwalk Crossing near the Visitors Center.

The Total number of recorded observations by recreator type for the entire field study was;

1 754 adult males
2 889 adult females
3 432 male children
4 381 female children

All information obtained was recorded on data sheets in the field, then later compiled into EXCEL data summaries. All of these records are provided in **Appendix B** of this document.

1.2 Roles, Responsibilities and Time-line

CMC NRMI was responsible for the following:

> Providing the necessary personnel for initial four tasks outlined within the Scope of Work (SOW). The personnel required for this effort include a Field Manager (Lisa Miller) within the NRMI program, oversight and guidance provided by the NRMI program administrator (Karmen King), and program accounting oversight by the NRMI contract administrator (Cathy Patti). All SOWs and agreements held between CMC NRMI and PHP will be reviewed and approved by both a CMC representative (Deborah Loper/Assistant Campus Dean/Timberline Campus) and the PHP representative (CAPT Charles Higgins/Director).

The NPS PHP was responsible for the following:

> Jason Thomas, Charles Higgins and other appropriate personnel will assist the CMC NRMI with all components of the Scope of Services (Tasks 1 through 4) where possible. Some of the initial data sets for each program may be obtained through PHP personnel. The Park point of contacts will be identified by the PHP who may also communicate initially to establish these efforts.
>
> The NPS PHP is responsible for the completion of Task 5 – Review of Documentation. The Technical memoranda will then be finalized as per comments provided by the NPS PHP, and Final documents will then be sent to appropriate entities (NPS PHP the parks, and whomever else the NPS PHP deems appropriate).

1.3 Document Format

This document follows the prescribed format required for a Human Health Risk Analysis as per Environmental Protection Agency – CERCLA Guidance (EPA, 1991 a and b). This Section describes the Purpose and Goals to the effort, as well as the methods for the collection of data relevant to the analysis (background and field). Section 2 describes the source, fate and transport of Coliform within the Medano creek system within the Great Sand Dunes National Park (the Park). Section 3 characterizes the exposure setting for the recreators observed at the park during the field event, and Section 4 folds all information together to define the risk to human health. Also within Section 4, is a description of the uncertainty associated with this analysis such as the data gaps encountered or assumptions applied. This document then summarizes the recommendations for next steps and any data gaps encountered during the course of this study.

Appropriate supplemental information to this document is provided in the Appendices which includes copies of additional data sets provided by the Park NPS (**Appendix A**) the field notes and data summaries from the exposure assessment field effort (**Appendix B**), copies of correspondence (**Appendix C**) and site photographs (**Appendix D**).

2 Source Characterization

Source characterization is the process of identifying the sources of the contaminants of concern (Coliform), their possible fate and transport mechanisms in the environment they are released to, and the ultimate media receptors could be exposed to.

A site conceptual model depicting the Coliform releases, transport mechanisms and exposure media is shown in **Figure 1, The Site Conceptual Model.**

Photo 2. Possible source of Coliform entering park at entrance gate.

2.1 The Great Sand Dunes National Park – Setting Description

The following information is a summarized version from the Great Sand Dunes Park Guide (NPS, 2004). The information gives a detailed summary of the park habitats and functions.

The Great Sand Dunes are the tallest sand dunes in North America which rise in a corner of the highest altitude in the San Luis Valley in the Colorado Rockies. These dunes have built to the heights of 750 feet from billions of grains of sand blown across the valley by wind and can cover 30 square miles. The streams and rivers from the San Juan Mountains to the west and the Sangre de Cristo Mountains to the east have carried eroded particles of sand and other sediments into the valley. Most of the waterways have changed course over time or flooded into large, shallow lakes that since have disappeared. Medano and Sand creeks, flowing out of the mountains, provide a further barrier to movement of the dune-field by carrying huge amount of sand back to the valley floor, where it is recycled back into the dunes by wind.

The active dune field blocks streams from flowing directly out of the Sangre de Cristo Mountains and into the San Luis Valley. As a result, only one main through-flowing drainage has developed on each side of the dune field. These are Sand Creek, which flows from the Music Pass area and is joined by tributaries along the north dune field perimeter, and Medano Creek, originating above Medano Pass and receiving several tributaries along the dune field's east perimeter. Both systems begin high in the mountains in glaciated valleys. The Medano creek system consists of 10 square miles of drainage basin, that becomes a braided channel as gradient lessens. Medano creek is up to 5.5 miles long, and 1,050 feet wide, covering a 0.76 square mile area. All of the

water in Medano Creek, except what is lost to evapo-transpiration, infiltrates into local aquifers. Water flow is gauged within Medano creek, and consistent recorded observations have been collected since July, 1991. Yearly maximum flows have been: 44 cfs in 1992; greater than flume capacity in 1993 (but estimated to be 100 cfs); and 73 cfs in 1994. More recent flow information is available, some of which is presented in the data provided by the NPS (**Appendix A**) (NPS, 1997).

It is the Medano creek system that is of particular interest and focus for this study. A majority of the visitors to the Park, will come in contact with the system. The amount and type of exposure experienced by the visitors can complete an exposure pathway to Coliforms, and pose a potential risk to the visitor. In regards to the creek system itself, under the State of Colorado classification system, nearly all park stream segments and wetlands fall under one specific set of designated use classifications and numeric standards. That numeric standards apply to physical and biological characteristics and content of metals and inorganic substances. These stream segments bear the State Use Classifications of: a) Class 1 – Cold Water Aquatic Life; b) Recreation Class 2 – Secondary Contact; c) Domestic Water Supply; and d) agriculture (State of Colorado, 1994a and b). Recreation Class 2 waters are suitable for limited contact, such as fishing and other streamside or lakeside recreation through which ingestion of water is not likely to occur.

2.2 Coliform Source Characterization

The source characterization for Coliform was addressed by evaluating the existing information documented in various studies obtained from the Background Research (refer to **subsection 1.2**), as well as from the data obtained during the sampling effort completed during the field effort. The following sections summarize the findings and describe the occurrence of Coliform throughout the park as evaluated by these studies.

Background Research

NPS, 1998 Baseline Study (NPS, 1998). All available data from STORET and others was compiled. Coliform was evaluated in numerous locations throughout the park. A summary of the results was compiled in **Table 1**. The results indicated:

- It was observed that Fecal-indicator bacterial concentrations (Fecal Coliform) exceeded the screening limits for freshwater bathing.
- Fecal Coliform concentrations were measured 32 times at 11 monitoring stations during 1992 and 1995.
- Twenty-three observations at ten stations within the park boundary (in Medano Creek and Little Medano Creek, and Medano Creek confluence) equaled or exceeded the bathing water screening criterion of 200 Colony Forming Units/Most probably Number per 100 milliliters (CFU/MPN/100 ml) during 1995.
- The highest value of 7,900 cfu/100 ml was reported in Medano Creek at the North Boardwalk in October, 1995.

NPS – Water Resources Management Plan (NPS, 1997). The NPS collected samples for common anion/cation, metals and water quality analysis. Locations were chosen to characterize tributary influences as well as the watershed as a whole. The report does not present any Coliform results, however the data obtained from the NPS (**Appendix A**) follows the sampling design described within this document.

USGS (Ferguson, 2003). Samples were analyzed for Fecal Coliform from locations throughout the Park (from May 1999 through September 2000). Results from the study are shown in **Table 2** and demonstrate the following;

1 Only one Fecal Coliform bacteria sample from Medano Creek below Mosca Creek exceeded 2,000 col/100 mL, and the geometric mean for that site did not exceed the instream standard.
2 Some individual measurements of Fecal Coliform concentrations were greater than 200 col/100 mL of sample, the geometric mean of the data did not exceed the instream standard of 200 col/100mL.
3 All of the samples that had concentrations greater than 200 col./100mL were collected during the summer during peak visitor activity.

Available data sets obtained from the Park are provided in **Appendix A,** and summarized in **Tables 3 and 4 (3 for 1995 through 1998, 4 for 2002 through 2004). Figures 3 and 4** summarize the data obtained directly from the NPS (Fred Bunch). There are two data sets demonstrated, **Figure 3** summarizes data gathered from 1995 through 1998, while **Figure 4** summarizes data from 1998 through 2004. Different analysis and interpretation methods were applied to these two sets. As shown on **Figure 3 and summarized in Table 3,**

1 The observed concentrations do <u>not</u> correlate to flow,
2 Areas with high recreator use are correlated to high occurrence of Coliform (N and S Boardwalk).
3 The only threshold exceedences occurred with data obtained from the 7/31/98 data set. This possibly reflects a high visitor/recreator effect to the water quality.

As shown in **Figure 4 and summarized in Table 4,**

- The method provides values depicting the 'most probable number' given the frequency of detection from replicate samples. There is no threshold for comparison against these results. The results provide an understanding of the possible frequency of occurrence of Coliform in samples collected. Given the observed results, most locations show a high likelihood of having Coliform present in the water.

<u>Field Effort</u>

Sampling of *E. Coli* and Coliform on June 8, 2004 from 14:25 to 17:30 and on June 9 from 8:35 to 11:45 was conducted with Katie Hagaman/NPS. The results are shown on Figure 4 as the data obtained from 6/8/04. Minimal detectable levels were observed in the samples collected. This may be due in part to the amount of flow present which could dilute the Coliform. Flow information was not available at the time of this document production.

3 Exposure Assessment

As previously described, in order for a person to be at risk to adverse effects from a contaminant, there must be a source, a complete exposure pathway and a receptor to the exposure. **Section 2** characterized the nature and extent of the source(s) of Coliform, while this section describes the possible exposure routes and receptors present within the Park.

As previously mentioned, the focus of this effort is to complete a risk analysis of Coliform exposure and effects to human health as related to Medano Creek. It does not evaluate other water systems such as the potable supply within the park. Discussions with Fred Bunch (**Appendix C – Correspondence**) and review of existing data (NPS, 1997) indicate that the primary potable supply with the park involves a series of wells. These wells have been studied and determined to sustain good water quality. One observed detection was noted by Fred Bunch, but disregarded for various reasons.

3.1 Exposure Pathways

There are three general routes of exposure by which human receptors can become exposed to water-borne contaminants such as Coliforms. These routes include inhalation, dermal contact and ingestion. Of these three routes in relation to exposure conditions associated with Medano creek, the two of most likely occurrence are dermal contact and ingestion. Inhalation would be a rare incidental occurrence for receptors given the fact that the contaminant (Coliform) is not volatile, and the opportunity for inhalation (i.e. from a shower or bathing) is highly unlikely. Similarly, dermal contact, while the most commonly occurring exposure pathway associated with this project, is not a tremendous concern in regards to Coliform. Pathogenic organisms rely on targeting a person's immune system and need to enter a person's body either via ingestion or perhaps through a dermal abrasion. The most likely of all the possible exposure pathways of concern, would be direct ingestion of Medano creek water. This is a complete pathway as noted by receptor behavior during the exposure observations taken for this study. It appears that the majority of visitors assume the creek has high water quality, since they are often observed 'washing their hands' and leaving the children to play for prolonged periods, directly within the flowing channel.

3.2 Receptor Populations

Photo 3. Kids playing in Medano Creek.

Photo 4. More kids playing in Medano Creek.

The NPS has conducted a variety of studies to determine the type of recreator use that occurs within the park (i.e. NPS, 2002). In fact, during the Field Effort, the park was in the midst of

completing a 'point of origin' survey of their visitors to determine the number of visitors from each state. The key component to a risk analysis is to identify the 'receptors' to exposure. Thus, it was necessary to conduct in-field observations of the recreators coming in contact with Medano Creek. As identified in the NPS, 2002 study, "91% of the park recreators went to the Dunes parking lot, and 84% to the visitor's center (currently adjacent to the Dunes lot) which have immediate access to Medano creek. In order to characterize exposure conditions within the creek at this key point, Lisa Miller was stationed at this area. She recorded the types of recreators, as well as the rate or durations of exposure. Summaries of the observed numbers of recreators/receptors during the field event are provided in **Tables 4 through 6 (also summarized in Appendix B – provided with the data summaries)**. **Table 4** summarizes observation events for the weekend of June 5 and 6, while **Table 5** summarizes observations during a weekday (June 10, 2004) and **Table 6** during another weekend of June 11 through 13, 2004. A summary of the types of recreator activity by day is as follows:

June 5th: At 10:00am through 2:00pm a continuous flow of traffic from the visitor center parking lot towards the Boardwalk Crossing at the Medano Creek was observed. Of these visitors, 30% of the family units that visited the park remained by the water for more than three hours, while 70% of the family units would cross the Boardwalk and head directly to the Dunes, making their contact rate 2-3 minutes. After 2:00pm and until 4:10pm family units would enter the crossing every few minutes. Activity by the water was a minimum. The weather remained warm with no wind.

June 6th: From 9:30am to 11:30am traffic remained slow. Family units did not establish themselves until 12:00pm or after, and remained by Medano Creek until 4:00pm. Approximately 30% of family units remained by Medano Creek, while 70% of the family units crossed the Boardwalk and headed towards the Dunes or to Upper Medano Creek.

June 7th: Observations were conducted at the Entrance Booth. From 9:45am to 11:00am traffic was steady, but slow. The majority of the visitors entering were either from foreign countries, or elderly individuals.

June 9th: Traffic remained steady from 2:10pm until 5:00pm. Individuals entering the park were small family units and groups of adults. The numbers of elderly were not as high as on June 7th.

June 10th: From 8:50am to 1:45pm traffic remained slow. There were extremely high winds and blowing sand. Contact near water was kept to a minimum. Family units would walk across for a duration time of less than 2-3 minutes. The wind calmed in the afternoon around 1:45pm and 10 family units began setting up by the creek, but still keeping creek contact to a minimum.

June 11th: High winds and cooler temperature throughout the morning. At 12:00pm warmer weather was occurring with little to no winds. 20% of the family units set up near the creek, while 80% of the family units continued to the dunes or upper Medano Creek.

June 12th: At 9:30am family units were filling the walkway from the visitor center to the Boardwalk crossing. From 9:30am to 12:00pm, 95% of family units migrated to the dunes, while 5% remained by the water. After 1:00pm, 40% of the family units set up by the creek, while 60% walked directly to the dunes or Upper Medano Creek. Children in the family units would remain in the water for an average period of 3 minutes.

June 13th: At 9:00am family units arrived slowly, but after 10:00am the traffic was high.

From 10:00am to 12:00pm 40% settled near the creek, while 60% migrated towards the dunes or upper Medano.

In summary, collectively some of the typical receptor activity, as well as unique observations can be described as follows;

1 About 40% of the children built sand castles, or lay in water for less than ten minutes.
2 30% of visitors observed cleaned off their hands in the creek water.
3 Approximately 70 to 80% of the visitors would cross the creek to access the Dunes.
4 A family unit cleaned their children's clothing in the creek.
5 A family unit of five washed their hands in a bucket of creek water before eating.
6 During the observation days, a considerable number of dogs were spotted, in addition to one horse.

Photo 5. A common scene while Medano Creek is flowing.

3.3 Rates of Exposure

During the Field Effort, it was qualitatively determined that a large percentage of the total park visitors were possible receptors to Medano creek water exposure since;

- The visitor center was temporarily housed within the Dunes access parking lot, thus compiling most of the visitors to an immediate access point to the creek,
- The weather was clear, and hot lending to visitors wanting to seek cooler temperatures at the Creek.

While these conditions are not unexpected, it is likely that a higher rate of visitor occurrence at the creek was a result during this study. In previous visitor surveys (NPS, 2002) lower visitor percentages were observed since they were drawn to the Visitor Center Loop Trail and Visitor Center which historically was located at the southern boundary to the park.

Once at the Dunes parking lot area, the majority of visitors accessed the visitor center, park facilities etc. A considerable portion then ventured towards the Dunes field via crossing Medano Creek. Most visitors were intent upon accessing the Dunes, thus limiting their rate of exposure to mere minutes (2-3 minutes) via dermal contact. A considerable portion of visitors however, focused their activities to the creek bed itself. These visitors would often set up a picnic area and let their children and pets frolic in the stream. A summary of the observed rates (time duration) of exposure and exposure routes (ingestion and dermal) is as follows;

- Between 65 – 90% of all recreators come in contact with Medano through direct contact exposure for 2-3 minutes.

- Adults and children show similar rates of direct contact in regards to duration. Children however, represent 99% of the recreators that are exposed via ingestion (192 children were observed ingesting water, while only one adult was observed).

- Between 0.3 to 9% of all recreators come in contact with Medano through incidental ingestion exposure.

4 Risk Analysis and Uncertainty Assessment

The Risk Analysis was completed by evaluating the exposure conditions as related to the Coliform nature and extent. In order for an effect to occur (or risk) there needs to be sufficient exposure to the source of a contaminant. As described in Section 2, the observed concentrations of total Coliform have been measured at various sites throughout the Medano creek area (refer to **Figure 2**). While recreators occur throughout the park, there are distinct areas where an abundance of activity occurs, thus the exposure (and source release) is more apparent.

It is important to consider than when evaluating human health risks associated with contaminant exposures, there are a number of considerations. It is important to consider not only the concentrations (or rate of occurrence as is the case for Coliforms), but also the sampling locations being representative in terms of realistic human exposure scenarios. If human receptors do not come in contact with the contaminants then the exposure cannot be considered complete. In the case of an incomplete exposure pathway, the risk of adverse health effects cannot be evaluated.

Risk was analyzed in this study by comparing observed Coliform concentrations to available thresholds protective of human health. Subsections 4.1 and 4.2 describe the epidemiology/toxicology of Coliform and the available thresholds for forms of Coliform. Finally, the data is analyzed in subsection 4.3 with a comparison of each obtained data set to the threshold values. The uncertainties associated with this analysis are also described.

4.1 Epidemiology/Toxicology of Coliform

Coliforms are organisms that often do not cause illness directly, but have demonstrated characteristics that make them good indicators of harmful pathogens in waterbodies. Following epidemiological studies conducted by EPA that evaluated the use of several organisms as indicators, including Fecal Coliforms, *E. coli* and *Enterococci*, EPA recommended in 1986 the use of E. coli for fresh recreational waters and enterococci for fresh and marine recreational waters because they were better predictors of acute gastrointestinal illness than fecal coliforms (refer to subsection 4.2 regarding thresholds).

The main route of exposure to illness-causing organisms, as related to Coliforms and others, in recreational waters is through direct contact with polluted water while swimming, or wading most commonly through accidental ingestion of the contaminated water (fecal – oral route). These illnesses result from the following:

1. Bacterial infection (such as *cholera, salmonellosis, shigellosis* and *gastroenteritis*),
2. Viral infection (such as infectious hepatitis, gastroenteritis, and intestinal diseases caused by enteroviruses),
3. Protozoan infections (such as *cryptosporidiosis, amoebic dysentery* and *giardiasis*).

Although the most common effects of bathing in contaminated water are illnesses affecting the gastrointestinal tract, other illnesses and conditions affecting the eye, ear, skin and upper respiratory tract can be contracted as well. With these conditions, infection often results when pathogenic microorganisms come into contact with small breaks and tears in the skin or ruptures in delicate membranes in the ear or nose resulting from diving into the water. These illnesses are not likely to be life-threatening for the majority of the population (EPA, 2002).

Of the different illnesses that may be contracted during recreational activities, gastrointestinal illness occurs most frequently (CDC, 2000; CDC, 1998). Gastroenteritis is a term for a variety of diseases that affect the gastrointestinal tract and are rarely life-threatening. Symptoms of the illness include vomiting, diarrhea, stomach ache, nausea, headache and fever. People who become ill as a result of swimming and wading, do not associate their illness with their activities since symptoms often appear several days after exposure and are often not severe enough to cause individuals to go to the hospital or see a doctor.

Of the vast number of species of microorganisms present in the environment, only a small subset are human pathogens, capable of causing varying degrees of illness in humans. While some human pathogens are naturally occurring in the environment, the source of these microorganisms is usually the feces or other wastes of humans and other warm-blooded animals. This demonstrates why Coliforms are an 'indicator' of potential pathogens (EPA, 2002).

4.2 Effects Levels by Type of Coliform and Receptor

For the protection of Human Health, several types of effects thresholds are published. The most standard being the Maximum Contaminant Level (MCL) for drinking water exposure (EPA National Ambient Water Quality Criteria). Other thresholds correlative to exposure type (dermal, ingestion or inhalation) or receptor category (female, male, elderly or children) can also be obtained from various literature sources. The following summarizes the thresholds available in the literature reviewed. This information is broken into two components: 1) criteria and 2) toxicological thresholds.

Criteria

Human Health MCL and MCLG for Drinking Water (source: EPA. Gov. Safewater. mcl: EPA, 1989). For the protection of drinking water/potable supplies both surface and groundwater, the following criterion limits apply:

1 Maximum Contaminant Level Goal (MCLG) – zero(1) The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals. Units are mg/L.

2 Maximum Contaminant Level (MCL) – 5.0% The highest level of a contaminant that is allowed in drinking water. The MCLS are set as close to MCLGs as feasible using the best available technology and taking cost into consideration. MCLs are enforceable standards. Units are mg/L.[fecal coliform and E. coli are bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Disease-causing microbes (pathogens) in these wastes can cause diarrhea, cramps, nausea, headaches or other symptoms. These pathogens may pose a special health risk for infants, young children and people with severely compromised immune systems.] Not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present. Coliforms are naturally present in the environment; as well as feces; fecal Coliforms and E. Coli only come from human and animal fecal waste.

(1) The 1998 Total Coliform Rule (TCR) set an MCLG of zero for total Coliforms because the EPA was not aware of any data supporting a particular value for the concentration of Coliforms below which any known or anticipated adverse health effects occur. Therefore, the TCR requires systems to monitor for total Coliforms at a frequency proportional to the number of people using the system. If any sample is total Coliform positive, the system must: 1) test the positive culture for the presence of either Fecal Coliforms or *E.coli*, 2) take one

set of 3-4 repeat samples at sites located within proximity to the positive detected location and 3) take at least five routine samples in the next month of operation.

State of Colorado – Numeric Water Quality Standards for Surface Waters of Great Sand Dunes National Monument (State of Colorado, 1994a and b: CDPHE 2001a and b). Exceedances of the instream standard for fecal coliform are determined by comparing the geometric mean of the data for each site to the Colorado instream standard. For the protection of the current classifications for the park, the following criteria apply:

1 2,000 colonies per 100 milliliters (col/100 mL) of sample water under the current classification; however under Outstanding Waters Designation, the instream standard for Fecal Coliform would be;
2 Fecal Coliform; 200col/100ml [the Fecal Coliform standard of 2000 per 100 ml has been established to provide general public health protection. There is no significant impact on domestic drinking water treatment plants because they provide complete disinfection. The standard of 200 per 100 ml is not intended to protect the water supply classification (CDPHE, 2003).]

National Recommended Water Quality Criteria for the protection of Human Health. Human health water quality criteria are numeric values that protect human health from the harmful effects of pollutants in ambient water. EPA's national recommended water quality criteria are guidance to states and authorized tribes in adopting water quality standards in support of the Clean Water Act (CWA). They are not regulations in themselves. There are no published criteria for the two human health water quality criteria of: 1) for consumption of water + organism, and 2) for the consumption of organisms only, since Coliforms do not bioaccumulate in aquatic organisms.

EPA, 2002 Ambient Water Quality Criteria for Bacteria (EPA, 2002; EPA, 1986, EPA, 1984). EPA believes the use of E. coli and/or enterococci are best suited to prevent acute gastrointestinal illness caused by the incidental ingestion of fecally contaminated recreational waterbodies. Regardless of source (animal or human), EPA feels there is human health issues associated with the potential waterborne pathogens. These criteria are DRAFT, however 18 states inclusive of Colorado have adopted the E.coli and/or enterococci criteria to protect all or part of their waters designated for recreation. The criteria adopted by the State of Colorado are as follows (Note: the segments of streams within the Park are classified as Secondary Contact Recreation Use, therefore the last criteria applies);

1 Recreation Use 1a (*E. coli*)
   - Geometric mean = 126 cfu/100 mL

2 Recreation Use 1b (*E. coli*)
   - Geometric mean = 205 cfu/100 mL

3 Secondary Contact Recreation Use (*E. coli*)
   - Geometric mean = 630 cfu/100 ml

Toxicological Thresholds

Seyfried et al., 1985: A freshwater study with a total of 4,537 individuals participated in a stuffy, of which 2,743 were swimmers and 1,794 were non-swimmers. Swimmers under the age of 16 had substantially higher rates of gastrointestinal illness than swimmers 16 and older. A small degree of correlation was observed between fecal streptococci and gastrointestinal illness.

Ferley et al., 1989. A freshwater study of 5,737 swimmers showed a good relationship between swimming-associated illness for both fecal coliforms and fecal streptococci. The strongest correlations occurred between incidence rates of acute gastrointestinal disease and fecal streptococci densities.

Haile et al., 1999 A marine water study of 11,686 subjects to determine associations between bacterial indicators and health outcomes when exposed via swimming. No positive associations were observed for E. coli at bacterial density thresholds of 35 and 70 cfu per 100 ml. The authors found that the total coliform to fecal coliform ratio was very correlative to disease. Using a ration of 5.0 as a threshold, diarrhea and highly credible gastrointestinal illness were associated with a lower total coliform to fecal coliform ratio regardless of the absolute level of fecal coliforms. Significantly higher risks were detected for most outcomes with total coliforms exceeding 5,000 cfu per 100 mL.

4.2 Data Analysis

The Data obtained from the Records review as well as the field effort was analyzed by comparing the observed concentrations to applicable threshold values. As summarized in subsection 4.2, there are a number of thresholds available, yet only a few have relevance to the Park itself. The thresholds used for the Data Analysis were:

State of Colorado – Numeric Water Quality Standards for Surface Waters of Great Sand Dunes National Monument (State of Colorado, 1994a and b: CDPHE 2001a and b, and CDPHE, 2003).

1. 2,000 col./ 100 mL (col/100 mL) for Total Coliform
2. 200 col./100mL for Fecal Coliform

EPA, 2002 Ambient Water Quality Criteria for Bacteria (EPA, 2002; EPA, 1986, EPA, 1984). EPA believes the use of E. coli and/or enterococci are best suited to prevent acute gastrointestinal illness caused by the incidental ingestion of fecally contaminated recreational waterbodies. Secondary Contact Recreation Use, therefore the last criteria applies);

1. Secondary Contact Recreation Use (*E. coli*) :Geometric mean = 630 cfu/100 ml

In summary, there are three applicable criteria that vary by type (Total Coliform, Fecal Coliform and *E. Coli*). The following provides an analysis of each data set obtained (presented in **Tables 1 through 5**)

Table 1. NPS Baseline Report (1998).

- The information compiled represents data obtained from federal databases prior to 1996. Three observations were collected for 10 sites located within the park boundaries. Results of the Coliform analysis were expressed in units of # Total Coliform/100 mL water, therefore the 2,000 col./100 mL criteria applies.

- Results indicate that there were three observations that exceed the 2,000 threshold. These were 'maximum' observed concentrations. However, at two of these locations, the average also exceeded the 2,000 threshold.

- The locations where exceedences were observed were: GRSA 0028, 0029 and 0033 (refer to Figure 2).

Table 2. (Ferguson, 2003) USGS 2002 water quality study.

- The information compiled represents a results from sampling events conducted from May 1999 through September 2000. All observations were measured in units of # Fecal Coliform/100 ml water, therefore the 200 col/100mL threshold applies.

- Results indicate that individual measurements of Fecal Coliform concentrations were greater than 200 theshold value, however the geometric mean of the data did not exceed the 200 value.

- All of the samples that had concentrations greater than 200 col/100mL were collected during the summer during peak visitor activity.

Table 3. (NPS, 1995) NPS provided data.

- The information compiled represents a results from three sampling events completed in 1995. All observations were measured in units of # Fecal Coliform/100 ml water, therefore the 200 col/100mL threshold applies.

- Results indicate that there were no exceedences of the observed concentrations as compared to the 200 threshold value.

Table 4. (NPS, 1998) NPS provided data.

- The information compiled represents a results from two sampling events completed in 1998. All observations were measured in units of # Fecal Coliform/100 ml water, therefore the 200 col/100mL threshold applies.

- Results indicate that five locations sampled on 07/31/98 exceeded the 200 threshold (locations 1, 3, 9, 10 and 11: Refer to **Figure 2**) with an observed maximum value of 350 col./100 mL. The data collected from the 10/15/98 sampling event all occurred bellow the threshold.

Table 5. (NPS, 2002 to 2004) NPS provided data.

- The information compiled represents a results from 7 sampling events completed from 2002 through 2004. All observations were measured in units of Most Probable Number (MPN), for which there is no comparable criteria. The data could not be evaluated in terms of criteria exceedence.

- Results from these measures are inconclusive given the inability to compare to available criteria.

Figure 3. (NPS, 1995 through 1998) NPS provided data

- The information compiled represents a results from four sampling events completed from 1995 through 1998 (and are summarized above). All observations were measured in units of # Fecal Coliform/100 ml water, therefore the 200 col/100mL threshold applies. The information provided in this Figure demonstrates the results by location for each event.

- Results indicate that high flows possible dilute the observed concentrations (ie 06/22/95 occurred at 70 cfs). The highest observed concentrations possibly correlate to the highest visitor occurrence rate. The boardwalk locations appear to show the highest rate of Fecal Coliform occurrence.

Figure 4. (NPS, 1998 through 2004) NPS provided data

- The information compiled represents a results from four sampling events completed from 1998 through 2004 (and are summarized above). All observations were measured in units of MPS for which there is no applicable threshold. The information provided in this Figure demonstrates the results by location for each event. There was no flow information available at the time of this report, therefore correlations could not be drawn.

- As shown within the Figure, the bracketing effect of the method makes the data sets appear comparable. It appears as though all sites during May and June demonstrate comparable values. It is difficult to draw any further conclusions in the absence of flow information.

4.3 Sources of Uncertainty

The sources of uncertainty involved with the data analysis occurred for two general reasons;

1) the methods of analysis have changed over time, thus the observed results 'units' vary (Total Coliform vs Fecal vs *E. Coli*).

2) The most recent method which derives an MPN value has merit, however the current available thresholds to determine human health are not caught up to the method, thus evaluation of risk could not be completed.

As summarized in subsection 4.2, there are three general thresholds applicable to the Park. Most of the information obtained from historic studies was expressed in either Total or Fecal Coliform levels. E.Coli measurements were not gathered, other than for 'presence or absence' (ie within the 2004 data set provided in Appendix A). The MPN values indicate a potential amount of Coliform and can not be interpreted.

5 Conclusions, Recommendations and Gap Analysis

The Park NPS first identified the Coliform issue and brought attention to their concerns (contact with NPS PHP). This project represents a risk analysis using existing information, in order to respond to these concerns. The Park itself continues to evaluate the nature and extent of the Coliform presence as part of their routine monitoring.

Our conclusions from this study are as follows;

2 The area with the highest observed concentrations of Coliform is collocated with the area of highest recreator contact and exposure. This poses two points: 1) it is possible that the recreators themselves are a component of the source, and 2) there is the potential for complete exposure and possible effects.

4 There are numerous sources (animal and human) as demonstrated by the nature and extent of Coliform occurrence. Backcountry areas show some of the highest concentrations, yet have the lowest rate of recreator contact. This indicates 'animal' sources are present.

5 It appears that Coliform occurrence is also related to flow within the Creek. Dilutional flows created by Spring snow-melt afford some level of protection by masking Coliform occurrence. This time period coincides with some of the highest rates of visitor occurrence, thus providing a protection against exposure.

5 The observed concentrations of Coliforms do exceed thresholds for the protection of human health in a minimal number of cases. The nature and extent of exceedences is discussed for each study in subsection 4.3. In summary of all these studies, the number of exceedences is rare overall, the general water quality is good and falls within criteria limit.

6 There is uncertainty with the ability of the NPS to track human health concerns due to the incompatibility of the method currently used which provides results in units of MPN. These values can not be directly compared to human health thresholds.

7 Times of year that are of concern would include holidays and weekends during the summer which correlate to high visitor activity and low flows. Areas or sites of concern are associated with the 'boardwalk' which is the highest use area, and contains some of the highest observed levels of Coliform.

8 Exposure, fortunately is very limited and occurs via dermal contact which is not a tremendous issue in regards to Coliform. As demonstrated in this study, the majority of visitors only incidentally become exposed. Concern however does arise from the fact that children do incidentally ingest water, and a complete exposure pathway does exist. It is this pathway that needs to be controlled if Coliform levels continue to rise (refer to recommendations).

There are uncertainties associated with these conclusions which can lead to over or under-conservative judgments. These include;

- Total Coliform, Fecal Coliform and *E. Coli* values are used for threshold comparisons and indications of risk. Coliform is an 'indicator' of the possible presence of fecal coliforms which may indicate the presence of pathogens. Thus, the presence of Coliform does not necessarily implicate the presence of the toxin or pathogenic organisms. The comparison of total coliform values to thresholds is therefore a very conservative estimate of risk.

- Exposure to Medano creek is severely limited. As per the results of this study, the majority of the recreators within the park are very briefly exposed to Medano water through dermal contact. Thus the majority is not at risk. There are the exceptions however, which occur with potentially compromised (children) receptors. The children left to play in Medano waters represent the most likely receptor population at risk, since they likely ingest the water.

- The data gathered from various studies are not comparable to each other, or at times, to available thresholds. Several units of measure (Total Coliforms, Fecal Coliforms and MPN) were gathered.

5.1 Recommendations

There are two key areas of recommendations that have resulted from this effort:

3) conduct further evaluation of Coliform occurrence to identify key source areas as well as seasonal and recreator impacts to the observed levels,
4) instigate a possible 'education' outreach to the visitors to assist with limiting possible sources and exposure pathways.

Further Source Characterization

As stated in the NPS, 1997 document, the Park proposed further evaluation of Coliform in their proposed project 'Determine Effects of Water-based and backcountry Recreation on Water Quality'. The park is currently in the midst of completing this project. The information provided herein could serve to supplement their baseline information for their forthcoming annual report. In addition to the Park's proposed plan, we suggest the following:

1. To conduct a sampling event on the weekends, during high visitor impact times
2. To conduct a sampling event on the first sign of flow in Medano Creek as a background, and continue sampling as described in the existing plan (implemented by the NPS).
3. Use a method of data analysis that yields actual values of Fecal Coliform, or E. Coli where possible

Education

An interesting facet to the NPS, 2002 "Visitor Study" was the evaluation of visitor understanding or education due to park materials and interpretive programs (NPS, 2002). High percentages of the visitors indicated that they learned a lot about a given topic from the materials and programs. This leads us to our second recommendation, to educate the visitors themselves.

There are two topics of education to be approached 1) controlling sources of coliform, and 2) controlling exposure. It regards to controlling sources of the Coliform, it is likely that the visitors themselves are a considerable source of the observed Coliform levels. Numerous direct observations of children in diapers, and pets left unattended were gathered during the field effort. Children are often left to play for prolonged periods without supervision. One direct observation of 'clothes washing' was noted, and several direct observations of pets and horses relieving themselves directly in the creek was also noted. At the same time, or within close proximity, visitors were observed to wash their hands, or douse their faces with creek water to cool themselves off, with no thought or concern of water quality.

It is very difficult to raise awareness of an issue such as water quality, or water-borne illness without raising undue concern. These topics may best be tackled by educating visitors in the methods of 'leave no trace'. Topics such as E.Coli and illnesses to children have captured Colorado audiences a number of times in recent years. A tactful description of possible illnesses related to water-borne pathogens may capture enough attention to assist with control of Coliform release and/or exposure.

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Tables

Table 1. Summary Statistics by Location for the NPS 1998 Baseline Study (# col/100 mL water) (source: NPS, 1998).					
Location	**Total of # of Observations**	**Median**	**Mean**	**Maximum**	**Minimum**
GRSA 0027	3	1300	1033.333	1700	100
GRSA 0028	3	800	2966.667	7900	200
GRSA 0029	3	3300	3000	4900	800
GRSA 0030	3	700	566.667	800	200
GRSA 0033	3	100	1700	4900	100
GRSA 0040	3	500	400	500	200
GRSA 0042	3	200	533.333	1300	100
GRSA 0043	3	200	533.333	1300	100
GRSA 0045	3	100	500	1300	100
GRSA 0049	3	200	433.333	900	200

Table 2: Summary Statistics of Fecal Coliform (col/100 ml water) by Location (Source: Ferguson, 2003)			
Location	**# of Samples**	**Minimum**	**Maximum**
Sand Creek @ the Baca Grant-Site 1	4	21	210
Sand Creek @ Monument Boundary-Site 2	5	<1	36
Medano Creek @ the Park Boundary-Site 3	24	<1	15
Buck Creek-Site 4	25	<1	140
Medano Creek below Garden Creek-Site 5	19	21	1600
Mosca Creek-Site 6	25	<1	62
Medano Creek below Mosca Creek-Site 7	25	21	2500
Cold Creek-Site 8	0	N/A	N/A
Little Medano at Mouth-Site 9	0	N/A	N/A
Castle Creek-Site 10	0	N/A	N/A
Sawmill Canyon-Site 11	0	N/A	N/A
Garden Creek-Site 12	0	N/A	N/A
Mosca Spring-Site 13	16	<1	17
Morris Gulch Spring-Site 14	23	<1	390
West Elk Spring Pond	0	N/A	N/A
N/A = Not Available			

Table 3. Summary Statistics for Data Obtained from the NPS (1995).			
	Fecal Coliform #/ 100mL		
	06-22-95	**08-7-95**	**10-12-95**
Boundary	2	9	2
Trail X-ing	1	13	1
Flume	2	13	1
Shockeys	2	1	13
Lt. Medano	5	2	5
Sand Pit	1	49	1
Bend	2	8	7
CG Trail	8	49	33
N. Boardwalk	2	8	79
S. Boardwalk	1	17	13
CFS @ Flume	70	10	2.5

Table 4. Summary Statistics for Data Obtained from the NPS (1998).		
Location	Fecal Coliform #/100 mL	
	07-31-98	10-15-98
1	240	2
2	140	<2
3	350	<2
4	110	2
5	130	4
6	49	<2
7	140	4
8	130	2
9	350	N/A
10	350	N/A
11	350	<2
N/A = Not Available		

Table 5. Summary Statistics for Data Obtained from the NPS (2002 through 2004).							
Location	MPN Index/100 mL						
	05-02-02	05-22-02	06-05-02	05-08-03	05-29-03	06-02-04	06-08-04 & 06-09-04
Site 1	<2.2	<2.2	2.2	16	>16	>16	>16
Site 2	<2.2	2.2	2.2	9.2	>16	>16	>16
Site 3	<2.2	<2.2	2.2	>16	>16	>16	>16
Site 4	<2.2	2.2	16	5.1	>16	16	>16
Site 5	<2.2	2.2	9.2	5.1	>16	16	>16
Site 6	5.1	<2.2	>	16	>16	>16	>16
Site 7	16.0	N/A	N/A	2.2	>16	>16	>16
Site 8	No water	N/A	5.1	9.2	>16	>16	>16
Site 9	No water	N/A	N/A	5.1	>16	>16	>16
Site 10	No water	N/A	N/A	16	>16	>16	>16
N/A = Not Available							

Table 6. Summary of Exposure Observations by Exposure Type, June 5 through June 13, 2004.					
Activity	**Adult**		**Child**		**Total**
	Male	Female	Male	Female	
Hiking	754	889	432	381	2456
Playing in water	3	6	137	134	280
Grand Total	757	895	569	515	2736
Rate of Exposure					
Direct Contact:					
2-3 minutes	590	677	370	308	1945
5 minutes	133	168	158	145	604
10 minutes	22	26	24	39	111
15 minutes	1	4	5	5	15
20 minutes	10	15	11	18	54
30 minutes	0	4	1	0	5
45 minutes	0	0	0	0	0
1 hour	0	0	0	0	0
2 hours	1	1	0	0	2
Grand Total	757	895	569	515	2736
Ingestion:	2	5	72	82	161

Horse: 1

Dogs: 134

*Played in water=running, sitting, standing,

*Hiking=Wading, or walking right across to the Dunes.

* Children are 17 and under

Table 8. Exposure Observations for 06/10/2004.					
Activity	**Adult**		**Child**		**Total**
	Male	Female	Male	Female	
Hiking	79	94	62	50	**285**
Playing in water	0	0	7	5	**12**
Grand Total	**79**	**94**	**69**	**55**	**297**
Rate of Exposure					
Direct Contact:					
2-3 minutes	73	86	59	49	**267**
5 minutes	6	8	10	6	**30**
10 minutes	0	0	0	0	**0**
15 minutes	0	0	0	0	**0**
20 minutes	0	0	0	0	**0**
30 minutes	0	0	0	0	**0**
45 minutes	0	0	0	0	**0**
1 hour	0	0	0	0	**0**
2 hours	0	0	0	0	**0**
Grand Total	**79**	**94**	**69**	**55**	**297**
Ingestion:	0	0	1	0	**1**

Dogs: 2

Comments: High winds, no long term activity in water.

Duration: June 10th: 8:50 to 13:45

Table 9. Exposure Observations for 06/11/2004 through 06/13/2004					
Activity	**Adult**		**Child**		**Total**
	Male	Female	Male	Female	
Hiking	410	510	263	232	**1415**
Playing in water	1	0	64	68	**133**
Grand Total	**411**	**510**	**327**	**300**	**1548**
Rate of Exposure					
Direct Contact:					
2-3 minutes	295	359	189	165	**1008**
5 minutes	96	118	118	100	**432**
10 minutes	10	11	7	16	**44**
15 minutes	1	4	2	2	**9**
20 minutes	9	14	10	17	**50**
30 minutes	0	4	1	0	**5**
45 minutes	0	0	0	0	**0**
1 hour	0	0	0	0	**0**
2 hours	0	0	0	0	**0**
Grand Total	**411**	**510**	**327**	**300**	**1548**
Ingestion:	0	0	35	42	**77**

Horse: 1

Dogs: 74

Comments: High winds on Friday and Saturday

Duration: **June 11th: 9:20 to 16:30**
June 12th: 9:30 to 16:25
June 13th: 9:00 to 12:00

Figures

Figure 1. Conceptual Site Model

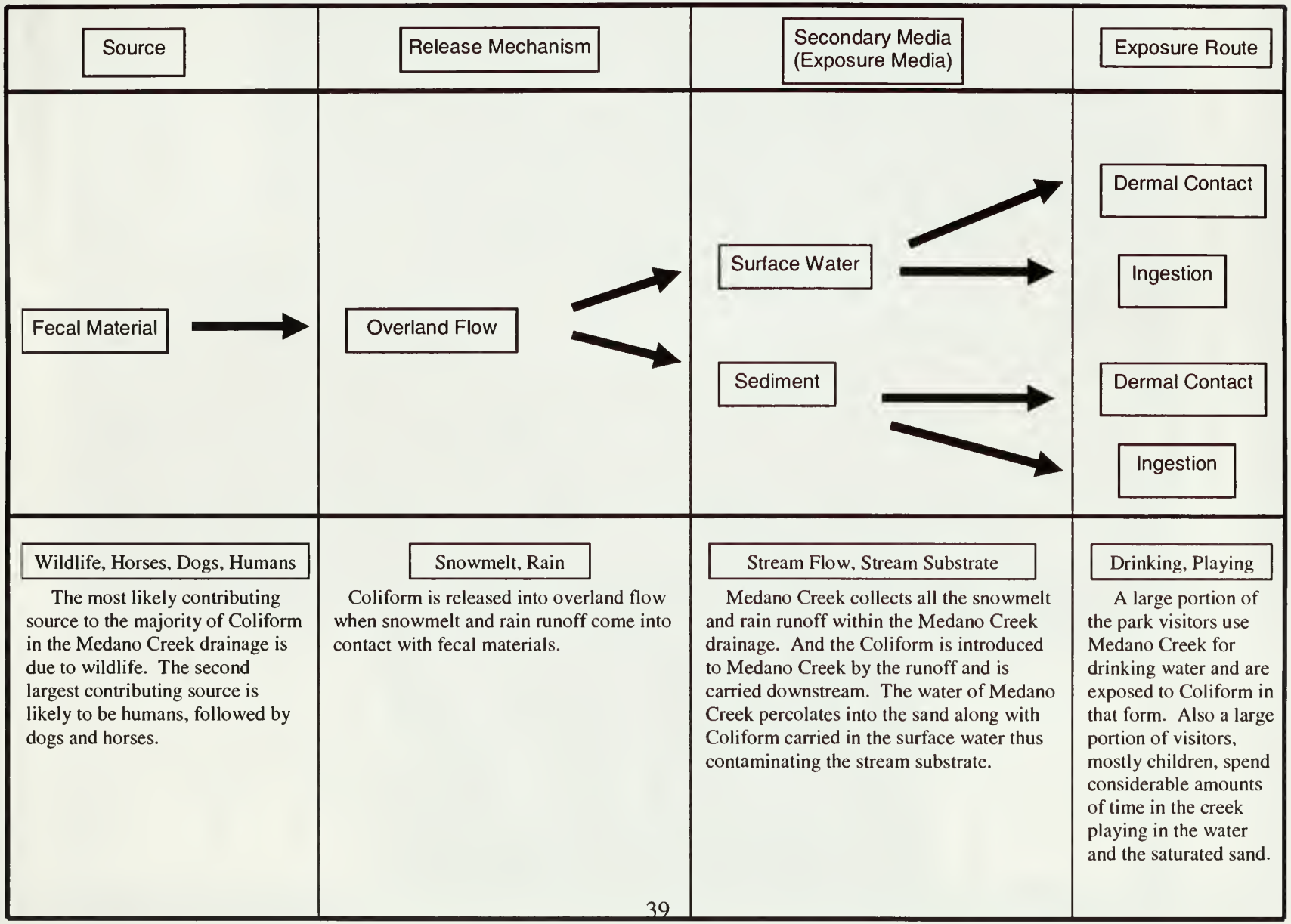


Figure 2. Locations for NPS Coliform Sampling (Baseline NPS, 1998 to

Figure 3. Fecal Coliform Levels 6/22/1995 through 7/31/1998

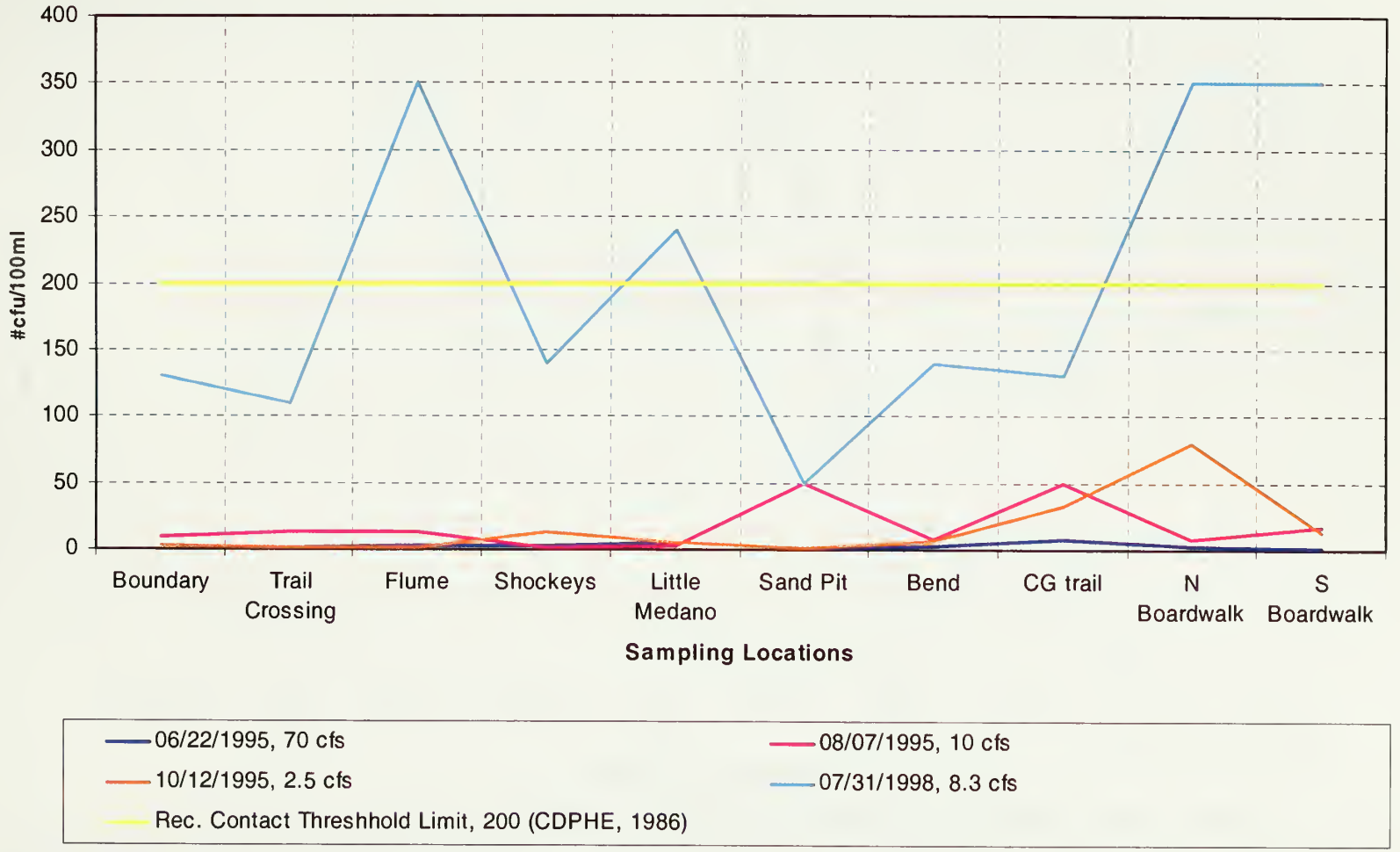
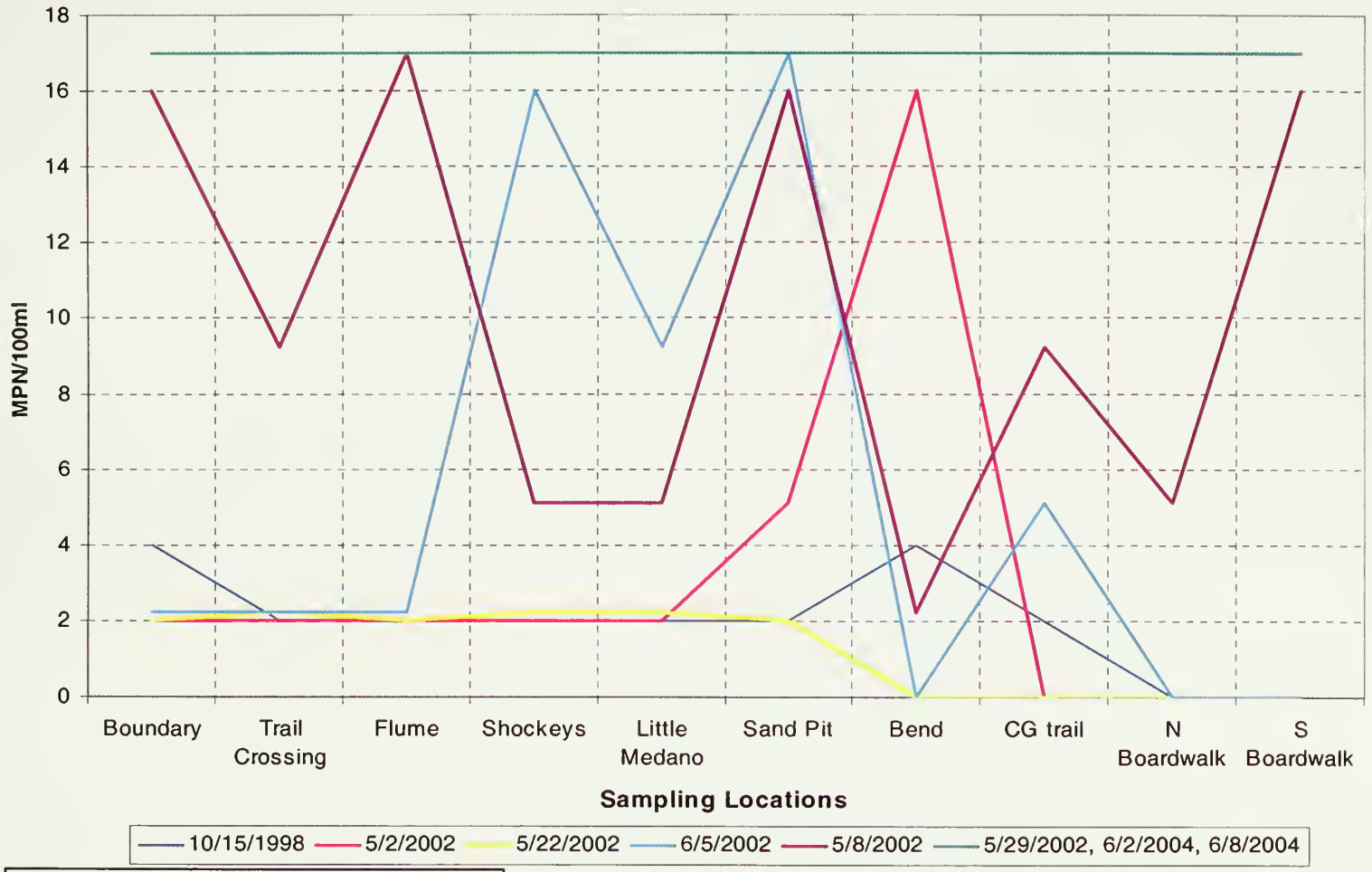


Figure 4. Fecal Coliform Levels 10/15/1998 through 6/8/2004



Values greater than 16 indicate MPN index >16
2 values indicate MPN index <2.2
0 values indicate no water to be sampled

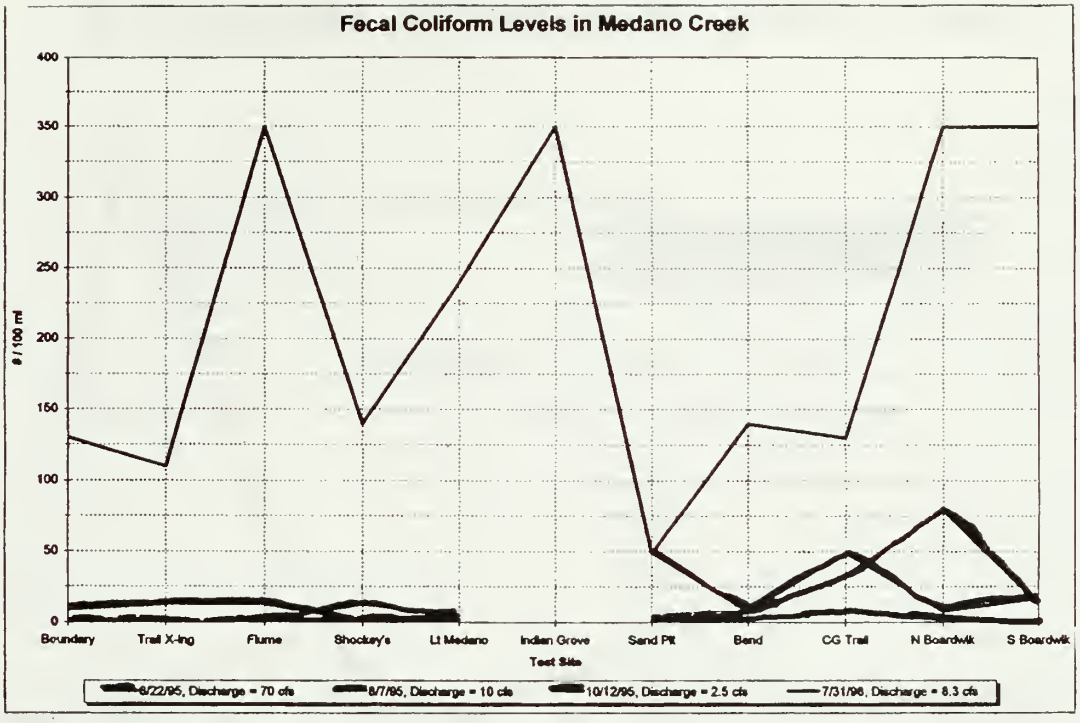
Appendix A

Copies of Additional Data and Methods of Collection

Results of Medano Creek fecal coliform bacte

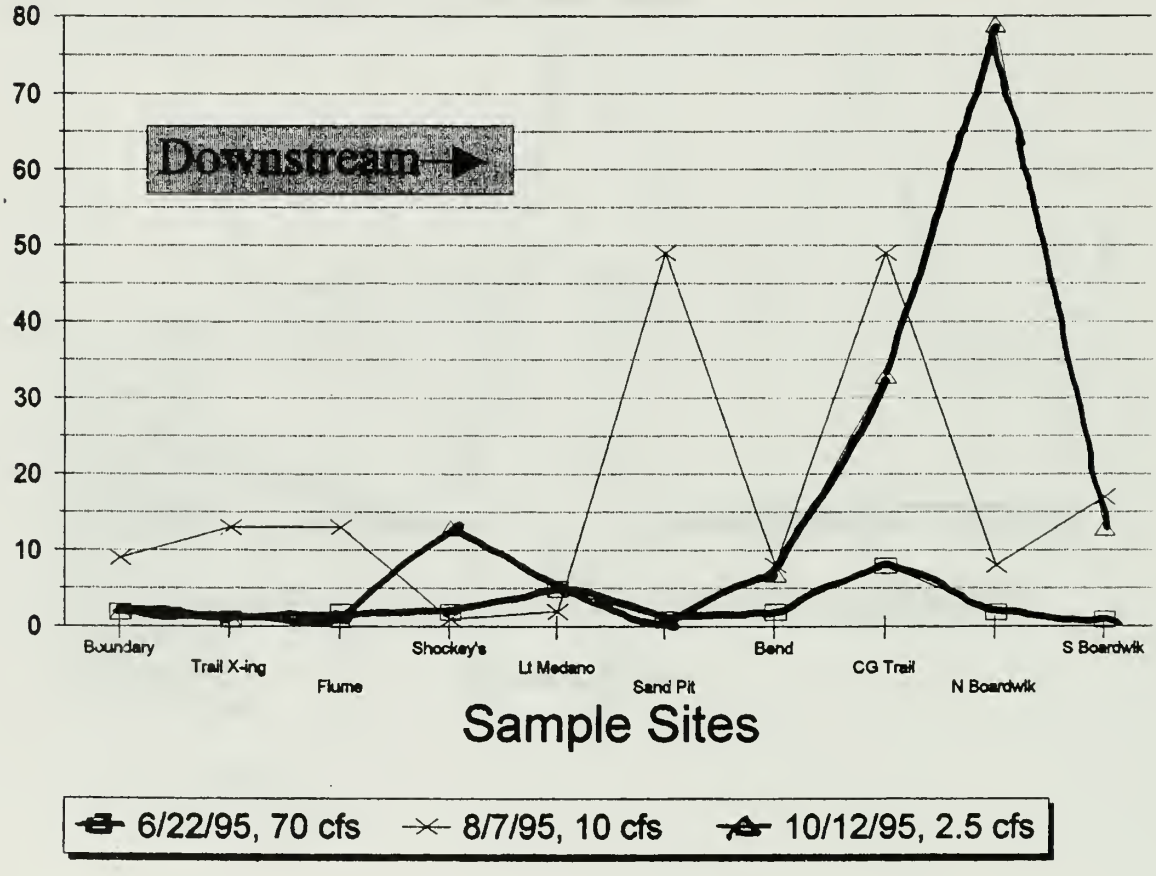
Site	Location	06/22/95 # / ml	08/07/95 # / ml	10/12/95 # / ml
5	Boundary	2	9	2
4	Trail X-ing	1	13	1
3	Flume	2	13	1
2	Shockey's	2	1	13
1	Lt Medano	5	2	5
6	Sand Pit	1	49	1
7	Bend	2	8	7
8	CG Trail	8	49	33
9	N Boardwlk	2	8	79
10	S Boardwlk	1	17	13
	CFS at flume	70	10	2.5

11 INDIAN GROVE Back Country Site



Prepared by Andrew Valdez 8/20/98

Fecal Coliform Measured in Medano Crk



TO: GREAT SAND DUNES NATIONAL MONUMENT
11500 HWY 150
MOSCA, CO
ATTN: FRED BUNCH

TEST RESULTS OF STREAM SAMPLES COLLECTED 7/31/98:

STATION CODE:	FECAL COLIFORMS: #/100 ML
1	240
2	140
3	350
4	110,
5	130
6	49
7	140
8	130
9	350
10	350
11	350

SLV ANALYTICAL SERVICES, INC.
P.O.BOX 150
ALAMOSA, COLORADO 81101
DATE: 8/6/98
PH: 719-589-9166

Mary Mueller, Gm

TO: GREAT SAND DUNES NATIONAL MONUMENT; 11500 Hwy 150; Mosca, CO
FROM: SLV ANALYTICAL SERVICES, INC.: P.O.BOX 150; ALAMOSA, CO 81101
DATE: 11/2/98

TEST RESULTS FOR STREAM SAMPLES COLLECTED AND TESTED ON 10/15/98:

STATION CODE:	FECAL COLIFORMS (#/100 ml):
1	2
2	<2
3	<2
4	2
5	4
6	<2
7	4
8	2
11	<2

SLV ANALYTICAL SERVICES, INC.
P.O.BOX 150
ALAMOSA, COLORADO 81101
PH: 589-9166
DATE: 11/2/98

Mary Mueller, gm

Current methods. FOR 5/2/02 to 6/10/04

MPN TESTING PROCEDURES

Test Procedure

- Sample bottles are to be filled at sampling site so that there is a minimum of 100mL of water. A total of ten (10) beakers will be filled for each sampling bottle.
- Once in the lab, the small test tubes containing the Colilert powders are to be filled with 10 mL of the sampled water. Four filled pipettes are needed to fill each test tube. The same pipette may be used repeatedly for the same sampling bottle. When filled, each pipette will yield 2.5 mL.
- Put the caps on the test tubes and shake vigorously until the solution is dissolved. Don't worry if all the powder in not dissolved, it will finish dissolving during incubation.
- Set the incubation temperature to 35 degrees C, plus or minus 0.5 degrees.
- Place test tubes in the incubator for twenty-four (24) hours.
- Remove test tubes from incubator and make sure the solutions are homogenous in color by turning test tubes upside down.

Test Results

- Compare the colors of the solutions in the test tubes to the color comparator. If the color in the test tube is darker than that of the comparator, there is presence of total coliforms or E. Coli.
- If the color of the test tube is lighter than that of the comparator, then the test is negative for both total coliforms and E. Coli.
- If there is presence of total coliforms or E. Coli, test to see which is present by holding the test tube about 3 – 5 inches from the fluorescent light, with the light facing away from your eyes.
- If the fluorescence is equal or greater than that of the comparator fluorescence, then E. Coli is present.
- If the fluorescence of the test tube is less than that of the comparator, then the test is considered to be negative for E. Coli, but still positive for total coliforms.
- If the test tube is the same color as the comparator, incubate up to but not to exceed 4 more hours, and compare. If there is still no difference, the test sample is considered to be negative.
- Throw away any sample that has been incubated for more than 28 hours.
- Use the chart enclosed with the Colilert tubes to find the confidence limits of the samples. For example: A set of samples having 4 positive reactions would yield a MPN Index per 100mL of 5.1.

Total Coliform / E. Coli Sampling – Medano Creek

Date Sampled: 5/2/02 Sampled By: Murphy, Sosinski

Date Tested: 5/3/02 Tested By: Sosinski

Location	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	MPN
Site 1	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	<2.2
Site 2	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	<2.2
Site 3	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	<2.2
Site 4	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	<2.2
Site 5	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	<2.2
Site 6	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	5.1
Site 7	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	16.0
Site 8	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	no water
Site 9	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	no water
Site 10	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	no water

MPN (Most Probable Number) Index and 95% Confidence Limits for Various Combinations of Positive and Negative Results When Five – 10 ml Portions are Used.

No. of Tubes Giving Positive Reaction Out of 5 of 10 ml Each	MPN Index/100 ml	95% Confidence Limits (Approximate)	
		Lower	Upper
0	<2.2	0	6.0
1	2.2	0.1	12.6
2	5.1	0.5	19.2
3	9.2	1.6	29.4
4	16.0	3.3	52.9
5	> 16.0	8.0	Infinite

Total Coliform / E. Coli Sampling – Medano Creek

Date Sampled: 5/22/02 Sampled By: Sosinski, Murphy
Date Tested: 5/23/02 Tested By: Sosinski

Location	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	MPN
Site 1	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	<2.2
Site 2	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	2.2
Site 3	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	<2.2
Site 4	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	2.2
Site 5	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	2.2
~~Site 6~~ Mosca	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	<2.2
Site 7	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	
Site 8	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	
Site 9	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	
Site 10	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	

MPN (Most Probable Number) Index and 95% Confidence Limits for Various Combinations of Positive and Negative Results When Five – 10 ml Portions are Used*

No. of Tubes Giving Positive Reaction Out of 5 of 10 ml Each	MPN Index/100 ml	95% Confidence Limits (Approximate) Lower	Upper
0	<2.2	0	6.0
1	2.2	0.1	12.6
2	5.1	0.5	19.2
3	9.2	1.6	29.4
4	16.0	3.3	52.9
5	> 16.0	8.0	Infinite

* Standard Methods for the Examination of Water and Wastewater, 17th edition. APHA • AWWA • WPCF • Denver, Colorado (1989)

note: incubating at 45°C

Total Coliform / E. Coli Sampling – Medano Creek

Date Sampled: 6/5/02 Sampled By: Murphy

Date Tested: 6/6/02 Tested By: Sasinski

Location	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	MPN
Site 1	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	2.2
Site 2	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	2.2
Site 3	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	2.2
Site 4	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	16
Site 5	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	9.2
Site 6	☐ Negative Positive ☑ E.Coli ☐ T. Coliform	☐ Negative Positive ☑ E.Coli ☐ T. Coliform	☐ Negative Positive ☑ E.Coli ☐ T. Coliform	☐ Negative Positive ☑ E.Coli ☐ T. Coliform	☐ Negative Positive ☑ E.Coli ☐ T. Coliform	>16
~~Site 7~~	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	
~~Site 8~~ Mosc1	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	5.1
~~Site 9~~	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	
~~Site 10~~	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	

MPN (Most Probable Number) Index and 95% Confidence Limits for Various Combinations of Positive and Negative Results When Five – 10 ml Portions are Used*

No. of Tubes Giving Positive Reaction Out of 5 of 10 ml Each	MPN Index/100 ml	95% Confidence Limits (Approximate)	
		Lower	Upper
0	<2.2	0	6.0
1	2.2	0.1	12.6
2	5.1	0.5	19.2
3	9.2	1.6	29.4
4	16.0	3.3	52.9
5	> 16.0	8.0	Infinite

* Standard Methods for the Examination of Water and Wastewater 17th edition APHA • AWWA • WPCF • Denver, Colorado (1989)

Total Coliform / E. Coli Sampling – Medano Creek

Date Sampled: 5/8/03 Sampled By: Sosinski

Date Tested: 5/9/03 Tested By: Sosinski

Location	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	MPN
Site 1	☐ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	16
Site 2	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	9.2
Site 3	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	716
Site 4	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	5.1
Site 5	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	5.1
Site 6	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	16
Site 7	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	22
Site 8	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	92
Site 9	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☑ Negative Positive ☐ E.Coli ☑ T. Coliform	☑ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	5.1
Site 10	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	16

MPN (Most Probable Number) Index and 95% Confidence Limits for Various Combinations of Positive and Negative Results When Five – 10 ml Portions are Used*

No. of Tubes Giving Positive Reaction Out of 5 of 10 ml Each	MPN Index/100 ml	95% Confidence Limits (Approximate)	
		Lower	Upper
0	<2.2	0	6.0
1	2.2	0 1	12.6
2	5.1	0 5	19.2
3	9.2	1.6	29.4
4	16.0	3.3	52.9
5	> 16.0	8.0	Infinite

* Standard Methods for the Examination of Water and Wastewater, 17th edition APHA • AWWA • WPCF • Denver, Colorado (1989)

Note: testing supplies were expired results may be incorrect.

incubator temp at 36°C

Total Coliform / E. Coli Sampling – Medano Creek

Date Sampled: 5/29/03 Sampled By: Babb, Sosinski

Date Tested: 5/30/03 Tested By: Babb, Sosinski

Location	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	MPN
Site 1	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☒ E.Coli ☐ T. Coliform	☐ Negative Positive ☒ E.Coli ☐ T. Coliform	☐ Negative Positive ☒ E.Coli ☐ T. Coliform	>16
Site 2	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☒ E.Coli ☐ T. Coliform	>16
Site 3	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☒ E.Coli ☐ T. Coliform	>16
Site 4	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☒ E.Coli ☐ T. Coliform	>16
Site 5	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☒ E.Coli ☐ T. Coliform	>16
Site 6	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☒ E.Coli ☐ T. Coliform	>16
Site 7	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☒ E.Coli ☐ T. Coliform	>16
Site 8	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	>16
Site 9	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☒ E.Coli ☐ T. Coliform	☐ Negative Positive ☒ E.Coli ☐ T. Coliform	>16
Site 10	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	>16

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		Lower	Upper
0	<2.2	0	6.0
1	2.2	0.1	12.6
2	5.1	0.5	19.2
3	9.2	1.6	29.4
4	16.0	3.3	52.9
5	> 16.0	8.0	Infinite

* Standard Methods for the Examination of Water and Wastewater, 17th edition, APHA • AWWA • WPCF • Denver, Colorado (1989)

Incubator temperature at 36 °C → Having difficulty regulating temp @ 35 ± 0.5 °C. Comparator is expired → may skew results.

Total Coliform / E. Coli Sampling – Medano Creek

Date Sampled: 06/02/2004 Sampled By: K. Hagaman

Date Tested: 06/03/2004 Tested By: K. Hagaman

Location	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	MPN
Site 1	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☒ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	>16
Site 2	☐ Negative Positive ☐ E Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	>16
Site 3	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	>16
Site 4	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	>16
Site 5	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	>16
Site 6	☐ Negative Positive ☒ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	>16
Site 7	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	>16
Site 8	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	☐ Negative Positive ☐ E.Coli ☒ T. Coliform	>16
Site 9	☐ Negative Positive ☒ E.Coli ☐ T. Coliform	☐ Negative Positive ☒ E.Coli ☐ T. Coliform	☐ Negative Positive ☒ E.Coli ☐ T. Coliform	☐ Negative Positive ☒ E.Coli ☐ T. Coliform	☐ Negative Positive ☒ E.Coli ☐ T. Coliform	>16
Site 10	☐ Negative Positive ☒ E.Coli ☐ T. Coliform	☐ Negative Positive ☒ E.Coli ☐ T. Coliform	☐ Negative Positive ☒ E.Coli ☐ T. Coliform	☐ Negative Positive ☒ E.Coli ☐ T. Coliform	☐ Negative Positive ☒ E.Coli ☐ T. Coliform	>16

MPN (Most Probable Number) Index and 95% Confidence Limits for Various Combinations of Positive and Negative Results When Five – 10 ml Portions are Used*

No. of Tubes Giving Positive Reaction Out of 5 of 10 ml Each	MPN Index/100 ml	95% Confidence Limits (Approximate)	
		Lower	Upper
0	<2.2	0	6.0
1	2.2	0.1	12 6
2	5.1	0 5	19.2
3	9.2	1.6	29.4
4	16.0	3.3	52.9
5	> 16.0	8.0	Infinite

* Standard Methods for the Examination of Water and Wastewater 17th edition APHA • AWWA • WPCF • Denver, Colorado (1989)

Total Coliform / E. Coli Sampling – Medano Creek

Samples 1-4 → 6/8/04pm
Date Sampled: 5-10 → 6/9/04am Sampled By: Hagaman, Miller
Date Tested: 6/10/2004 Tested By: Busch, Miller

Location	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	MPN
Site 1	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	>16
Site 2	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	>16
Site 3	☐ Negative Positive ☑ E.Coli ☐ T. Coliform	☐ Negative Positive ☑ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	>16
Site 4	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☑ E.Coli ☐ T. Coliform	☐ Negative Positive ☑ E.Coli ☐ T. Coliform	☐ Negative Positive ☑ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	16
Site 5	☑ Negative Positive ☐ E.Coli ☐ T. Coliform	☐ Negative Positive ☑ E.Coli ☐ T. Coliform	☐ Negative Positive ☑ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	16
Site 6	☐ Negative Positive ☑ E.Coli ☐ T. Coliform	☐ Negative Positive ☑ E.Coli ☐ T. Coliform	☐ Negative Positive ☑ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	>16
Site 7	☐ Negative Positive ☑ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	>16
Site 8	☐ Negative Positive ☑ E.Coli ☐ T. Coliform	☐ Negative Positive ☑ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	>16
Site 9	☐ Negative Positive ☑ E.Coli ☐ T. Coliform	☐ Negative Positive ☑ E.Coli ☐ T. Coliform	☐ Negative Positive ☑ E.Coli ☐ T. Coliform	☐ Negative Positive ☑ E.Coli ☐ T. Coliform	☐ Negative Positive ☑ E.Coli ☐ T. Coliform	>16
Site 10	☐ Negative Positive ☑ E.Coli ☐ T. Coliform	☐ Negative Positive ☑ E.Coli ☐ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	☐ Negative Positive ☐ E.Coli ☑ T. Coliform	>16

Testing Time = 2:40
Temp = 37°

Starting Temp = 35.5
Testing Time = 2:00pm

MPN (Most Probable Number) Index and 95% Confidence Limits for Various Combinations of Positive and Negative Results When Five – 10 ml Portions are Used*

No. of Tubes Giving Positive Reaction Out of 5 of 10 ml Each	MPN Index/100 ml	95% Confidence Limits (Approximate)	
		Lower	Upper
0	<2.2	0	6.0
1	2.2	0.1	12.6
2	5.1	0.5	19.2
3	9.2	1.6	29.4
4	16.0	3.3	52.9
5	> 16.0	8.0	Infinite

* Standard Methods for the Examination of Water and Wastewater 17th edition. APHA • AWWA • WPCF • Denver, Colorado (1989)

Great Sand Dunes National Monument and Preserve
Bacteria Testing

Sample #	Collection Site
1.	Medano Creek at Boundary UTM X: 456217, Y: 4183649
2.	Medano Creek at trail crossing UTM X: 456007, Y: 4183459
3.	Medano Creek at flume UTM X: 455801, Y: 4183285
4.	Medano Creek at Shockey's Crossing UTM X: 455582, Y: 4183037
5.	Medano Creek below Little Medano confluence UTM X: 455173, Y: 4182847
6.	Medano Creek at Sand Pit UTM X: 455323, Y: 4179470
7.	Medano Creek at front country bend UTM X: 454870, Y: 4178331
8.	Medano Creek at Campground trail UTM X: 454808, Y: 4177636
9.	Medano Creek at North Boardwalk UTM X: 456217, Y: 4183649
10.	Medano Creek 300ft. south of South Boardwalk UTM X: 454440, Y: 4176695

B.1 Exposure Characteristics

Four days of weekend observations were conducted at the Boardwalk Crossing near the visitor's center. Each field observation was conducted in the same method, as far as filling out data sheets and similar field time. There was one weekday observation that was conducted. The field time, date and results are listed below:

Weekend:

Saturday, June 5, 2004	from 9:30 to 16:10
Sunday, June 6, 2004	from 9:30 to 15:30
Friday, June 11, 2004	from 9:20 to 16:30
Saturday, June 12, 2004	from 9:30 to 16:25
Sunday, June 13, 2004	from 9:00 to 12:00

Weekday:

Thursday, June 10, 2004 from 8:50 to 13:45

- Friday, June 11 was placed into the weekend count due to suggestions made by Fred Bunch of the GRSA indicating that Friday is considered a weekend day.
- Sunday, June 13 was the last day of field observation and due to that the day ended at 12:00.

The information listed below was taken from the data sheets that were filled out for each family unit which are broken out by day.

Saturday, June 5th and Sunday, June 6th:

# Of individuals hiking through Medano creek:	756
# Of individuals playing in water:	135
# Of individuals in water for 2-3 minutes:	670
# Of individuals in water for 5 minutes:	142
# Of individuals in water for 10 minutes:	67
# Of individuals in water for 15 to 20 minutes:	10
# Of individuals in water for more than 20 minutes:	2
# Of individuals ingesting water:	83

Thursday, June 10, 2004:

# Of individuals hiking through Medano creek:	285
# Of individuals playing in water:	12
# Of individuals in water for 2-3 minutes:	267
# Of individuals in water for 5 minutes:	30
# Of individuals in water for 10 minutes:	0
# Of individuals in water for 15 to 20 minutes:	0
# Of individuals in water for more than 20 minutes:	0
# Of individuals ingesting water:	1

Friday, June 11
Saturday, June 12
Sunday, June 13

# Of individuals hiking through Medano creek:	1415
# Of individuals playing in water:	133
# Of individuals in water for 2-3 minutes:	1008
# Of individuals in water for 5 minutes:	432
# Of individuals in water for 10 minutes:	44
# Of individuals in water for 15 to 20 minutes:	59
# Of individuals in water for more than 20 minutes:	5
# Of individuals ingesting water:	77

- All number listed above are combined with male, females and male and female children.
- In appendices 1.1 are the summary sheets broken out by sex and duration
- Information was collected by observing activity within the Medano Creek at the Boardwalk crossing near the visitor's center.

Table. B.1 Summary by Exposure Type (June 5 and 6, 2004)

Saturday June 5th through Sunday June 6th

Activity	Adult		Child		Total
	Male	Female	Male	Female	
Hiking	265	285	107	99	**756**
Playing in water	2	6	66	61	**135**
Grand Total	**267**	**291**	**173**	**160**	**891**
Rate of Exposure					
Direct Contact:					
2-3 minutes	222	232	122	94	**670**
minutes	31	42	30	39	**142**
10 minutes	12	15	17	23	**67**
15 minutes			3	3	**6**
20 minutes	1	1	1	1	**4**
30 minutes					
45 minutes					
1 hour					
2 hours	1	1			
Grand Total	**267**	**291**	**173**	**160**	**891**
Ingestion:	2	5	36	40	**83**

***Dogs:** 58

Duration: **June 5th: 9:30 to 16:10**

June 6th: 9:30 to 15:30

Table. B.2 Summary by Exposure Type (June 10, 2004)

Thursday, June 10, 2004

Activity	Adult		Child		Total
	Male	Female	Male	Female	
Hiking	79	94	62	50	**285**
Playing in water			7	5	**12**
Grand Total	**79**	**94**	**69**	**55**	**297**
Rate of Exposure					
Direct Contact:					
2-3 minutes	73	86	59	49	**267**
5 minutes	6	8	10	6	**30**
10 minutes					
15 minutes					
20 minutes					
30 minutes					
45 minutes					
1 hour					
2 hours					
Grand Total	**79**	**94**	**69**	**55**	**297**
Ingestion:	0	0	1	0	**1**

***Dogs:** 2

***Comments:** High winds, no long term activity in water.

***Duration: June 10th: 8:50 to 13:45**

Table. B.3 Summary by Exposure Type (June 11 through 13, 2004)

Friday, June 11, Saturday, June 12 and Sunday, June 13

Activity	Adult		Child		Total
	Male	Female	Male	Female	
Hiking	410	510	263	232	**1415**
Playing in water	1	0	64	68	**133**
Grand Total	**411**	**510**	**327**	**300**	**1548**
Rate of Exposure					
Direct Contact:					
2-3 minutes	295	359	189	165	**1008**
5 minutes	96	118	118	100	**432**
10 minutes	10	11	7	16	**44**
15 minutes	1	4	2	2	**9**
20 minutes	9	14	10	17	**50**
30 minutes		4	1		**5**
45 minutes					
1 hour					
2 hours					
Grand Total	**411**	**510**	**327**	**300**	**1548**
Ingestion:	0	0	35	42	**77**

***Horse:** 1

***Dogs:** 74

***Comments:** High winds on Friday and Saturday

Duration: **June 11th: 9:20 to 16:30**
June 12th: 9:30 to 16:25
June 13th: 9:00 to 12:00

***Key:**

***Ingestion:** Buckets of water poured on head; face down in water, being splashed, wiping face with water, and washing hands in water.
***Playing in water:** Running, sitting or standing.
***Hiking**: Wading, or walking right across to the Dunes.
Children are 17 and under.

6/9/04 GRSA

6/5/04 GRSA 19/80

Time: 09:30 to 16:10
Location: Boardwalk location
By visitors center.

PURPOSE: to observe
human and animal
recreation contact with
meadano creek.
Team: L. miller, K. King, M. Thompson
weather: warm/sunny.

Comments: High traffic
in the water. most
people spending less
than 5 min. on
in water.

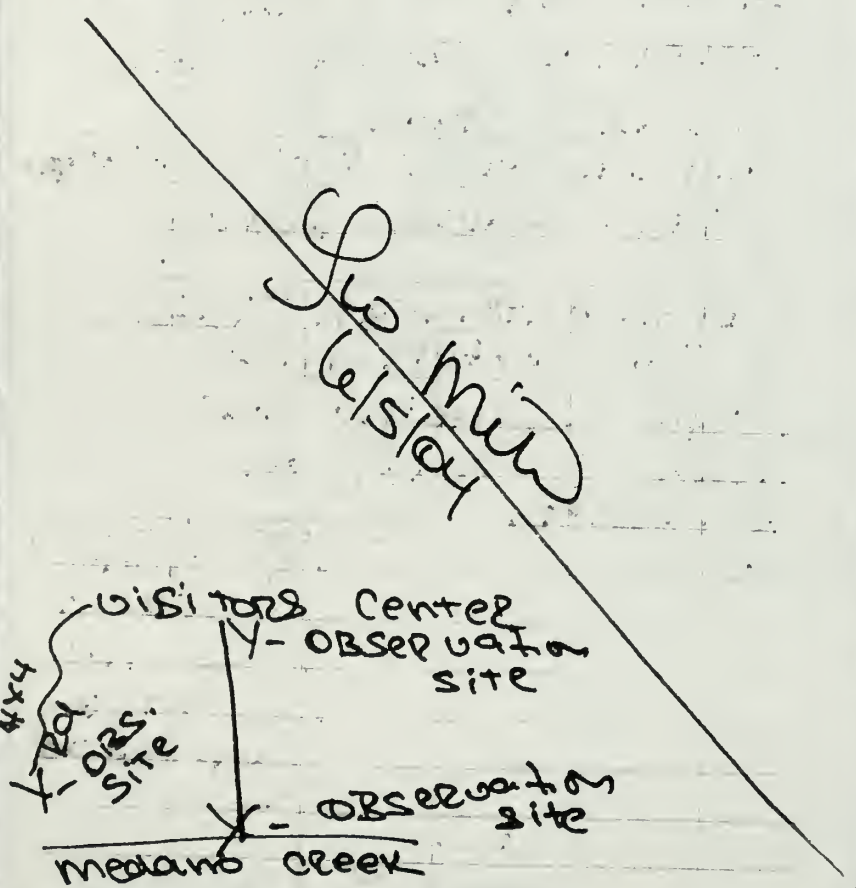
OBSERVATIONS
also taken
By mike T.
on the 4x4
Pol, and By
Camp grounds.

6/5/04

6/5/04 GRSA. Cont.

-Comments:

Karmen King observed visitors from Entrance Booth from 09:00 to 13:30



6/6/04 GRSA 20/80

Time: 09:30-15:20

Location: Boardwalk crossing.

Purpose: To observe human and animal contact with Medano Creek.

Team: Lisa Miller
Karmen King
Mike Thompson.

Weather: warm/sunny.

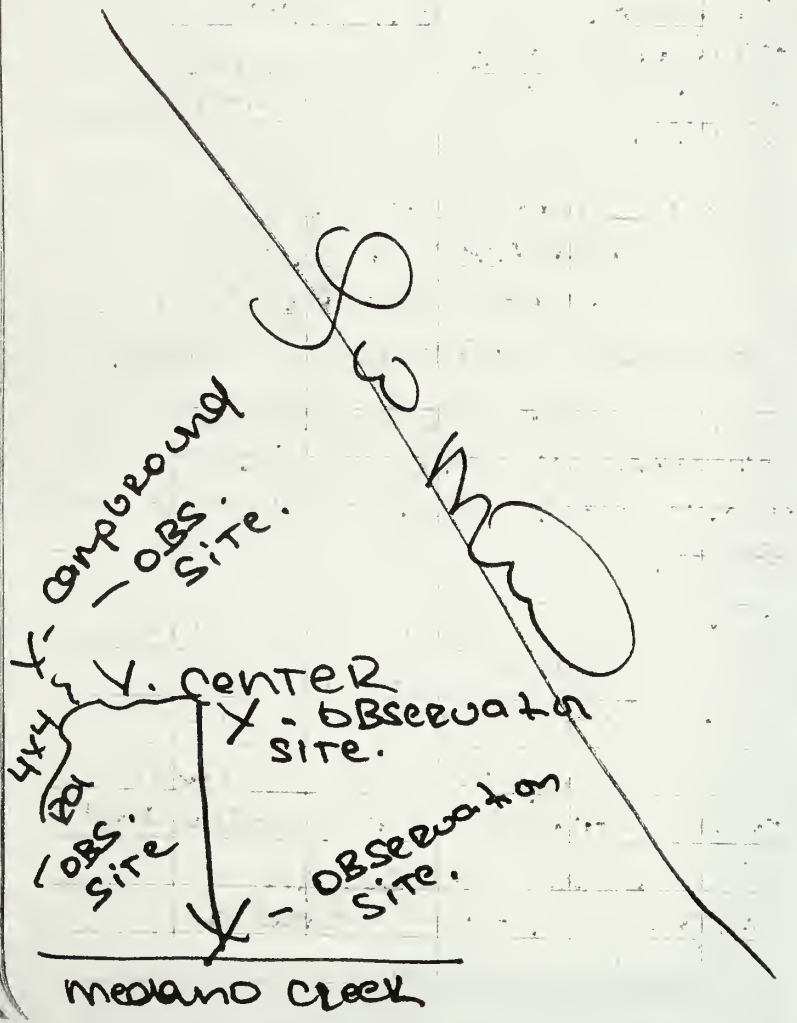
Lisa Miller- Observed Humans/animals from Boardwalk from 09:20 to 5:30.

Karmen King: Observed people from Entrance Booth. From 09:30 - 12:00

Mike Thompson- Observed people from Camp ground, 4x4 Road and in Entrance Booth from 09:30 - 12:00.

6/6/04 GRSA

Data Sheets were filled out at each location.



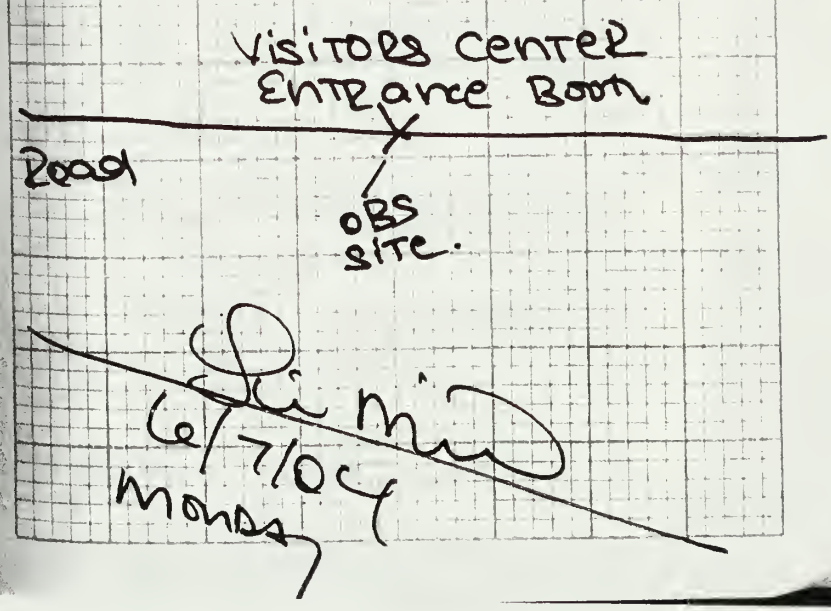
6/10/04 GRSA 21/80

Time: 09:45 - 17:00

Weather: Sunny/warm

Purpose: Observe Traffic Entering Park. Fill out Data Sheets with information such as sex, animals, and # of people in car, point of origin.

Team: Lisa Miller



6/8/04 GRSA

Blank Page

6/8/04 GRSA 5/80

Team: Lisa miller
Katie Hagman-
GRSA.

Weather: Sunny, Clear, 90°

START Time: 12:30

Purpose: To Collect WQ, Alkalinity, Hardness and Dissolved oxygen from 10 park locations. Observe coliform Sampling methods and Collection with Kate Hagman.

Sites on Following pages

Kit #3 Completed @ 11:30

ph 4.01 → 4.00 @ 22.5
7.00 → 6.95 @ 20.2
10.00 → 9.84 @ 20.9

Cond 447 → 446 @ 20.9
1413 → 1403 @ 20.4
12.88 mS → 12.85 @ 20.5

6/8/04 GRSA

Sw Mus
6/8/04
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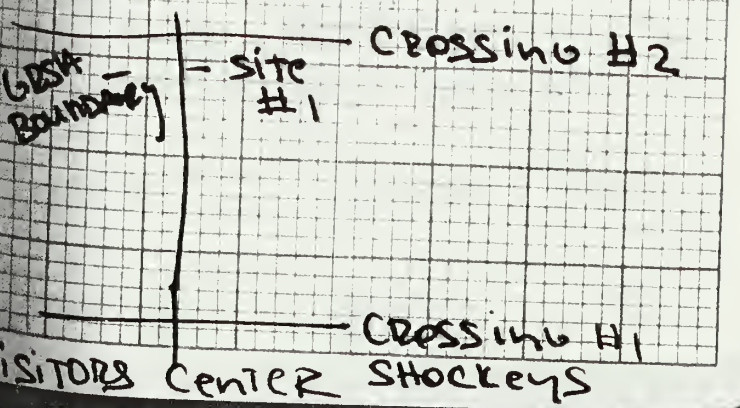
Page

6/8/04 GRSA 9/80

SITE: #1 Time: 14:25
Location: Take Mosca 4X4 Road. heading away From visitors center. on Right hand side, across From GRSA PARK Boundary Sign.

Ph: 6.70
Cond: 86.9
Temp: 15.4

Alk: 87 X.4 = 34.8 mg/L
Hard: 92 X.4 = 36.8 mg/L
D.O: 18 / .10 = 1.8



6/8/04 GRSA

Jim ... 6/8/04
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6/8/04 GRSA 7/80

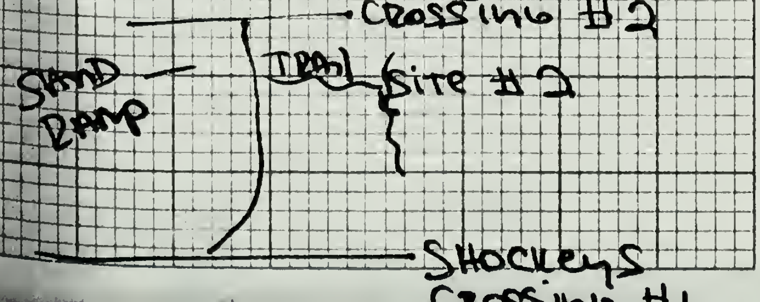
Site #2 Time: 15:05

Location: Directly across from Sand Ramp, follow Trail sign, up stairs, and follow Horse sign on left.

Ph: 6.96
Cond: 88.6
Temp: 16.3

Alk: 104 X .4 = 41.6 mg/L
Hard: 67 X .4 = 26.8 mg/L
Do: 22 / 10 = 2.2

Comments: ph screen was unreadable for a few minutes. After that it was readable again.



9/8/04 GRSA

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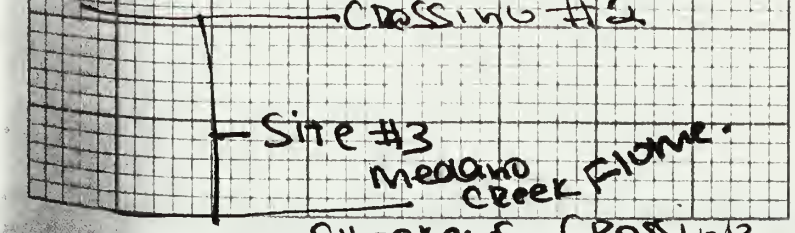
Lisa Mun 6/8/04

6/8/04 GRSA 8/8

Site: 3 Time: 15:40
Location: Medano Flume crossing.

Ph: 7.22
Cond: 873
Temp: 16.4
Alk: 80 X .4 = 32.0 mg/L
Hard: 192 X .4 = 76.8 mg/L
DO: 18 1.10 = 1.8

Comments: Hardness Buffer solution leaked on all bottles and packets. Completed Hardness, Alk, and DO and parking lot due to ants. Hardness results high due to spill.



6/8/04 LRSA

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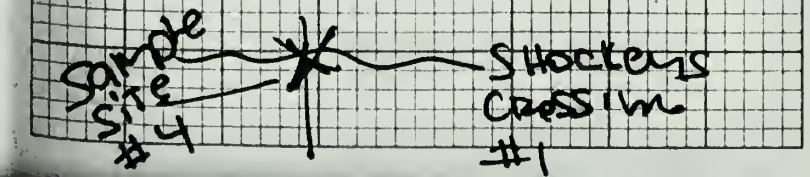
6/8/04 LRSA 9/8

Site #4 Time: 17:30

Location: Middle of High Flow in Stockleys Crossing.

AIK: 90 x .4 = 36.0 mg/L
HARD: 90 x .4 = 36.0 mg/L
DO: 60 / 1.10 = 6

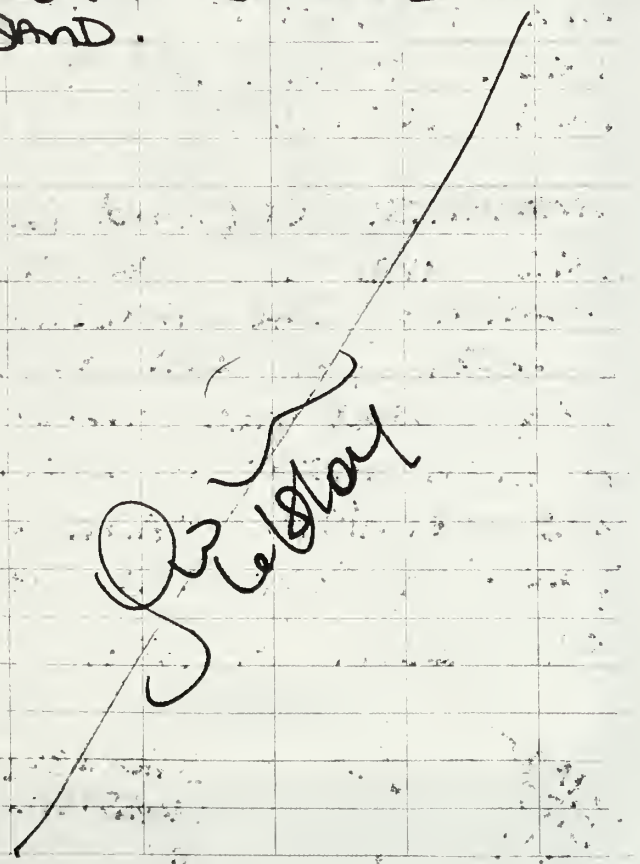
Comments: Completed AIK, HARD and DO after cleaning the Hardness buffer. Ph, Cond and Temp was not taken Due to high flow in River, and Dechick wanting to pass. Ph, Cond and Temp was taken 6/9/04.



6/8/04 GRSA

Comments:

A Delay was The ~~Result time~~ of almost two hour Difference Between Sample three and Sample four, Due to vechieles Stuck in Sand.



6/8/04 GRSA 10

E.O.D.S:

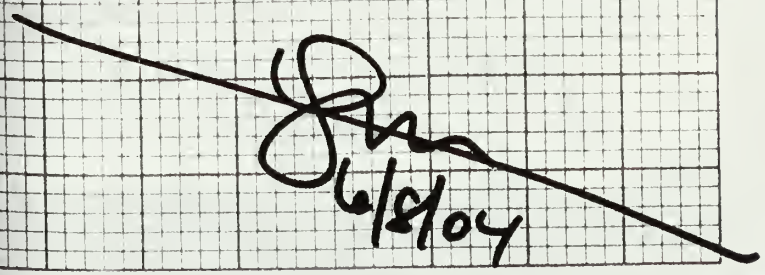
Post Drift @ 18:40

1.01 → 9.06 @ 28.3
7.00 → 6.95 @ 27.9
10.00 → 9.82 @ 28.1
Cond: 447 → 536 @ 28.6
1413 → 1407 @ 27.8
12.88 → 12.07 @ 28.1

Samples @ Sites 1, 2, 3 and 4

Collected WQ @ all sites except For Site #4. will Collect on 6/9/04

Hardness Solution Burst and Spilled on equipment. Ended Day Due That and Time Restrications.



6/8/04

6/8/04 GRSA

6/8/04
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6/9/04 GRSA 11/8

Team: Lisa Miller
Katie Hagman - GRSA PARK

START time: 07:10 AM.
Weather: Clear, 65° (car clock)
Purpose: to collect WQ, Hard, Alkalinity, Dissolved oxygen and observe methods for Coliform Sampling. Sites on following pages.

Kit #3, meter #3

~~Site #4~~ ~~Time: 08:35~~

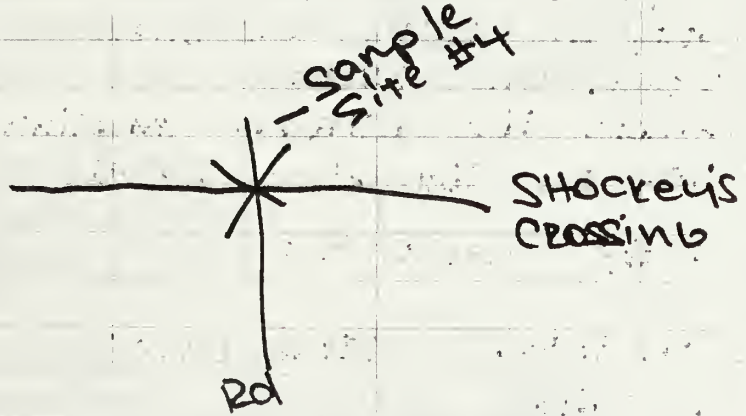
Pre-Diff
Ph 4.01 → 4.09 @ 19.9
7.00 → 6.99 @ 20.4
10.00 → 9.94 @ 18.9

Cond: 447 → 44000 18.5
~~1387 →~~
1413 → 1387 @ 19.2
12.88 → 12.86 @ 17.7

6/9/04 GRSA

Site #4 Time: 08:35

Ph: 7.69
Cond: 99.4
Temp: 9.3



6/9/04 GRSA 12/80

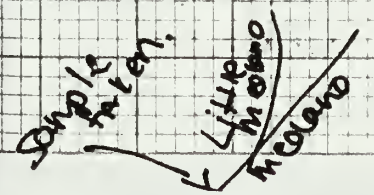
Site #5 Time: 08:45 to 09:05

Location: Confluence of medano and little medano.

Ph: 7.69
Cond: 83.5
Temp: 9.0

AIL: 94 x .4 = 37.6 mg/L
HARD: 96 x .4 = 38.4 mg/L
DO: 85 % .10 = 8.5

Comments: took photos of Little medano and medano joining. Sample was taken 10ft Down stream from Confluence.



6/9/04 LBSA

Site #16 Time: 09:30 to 09:50

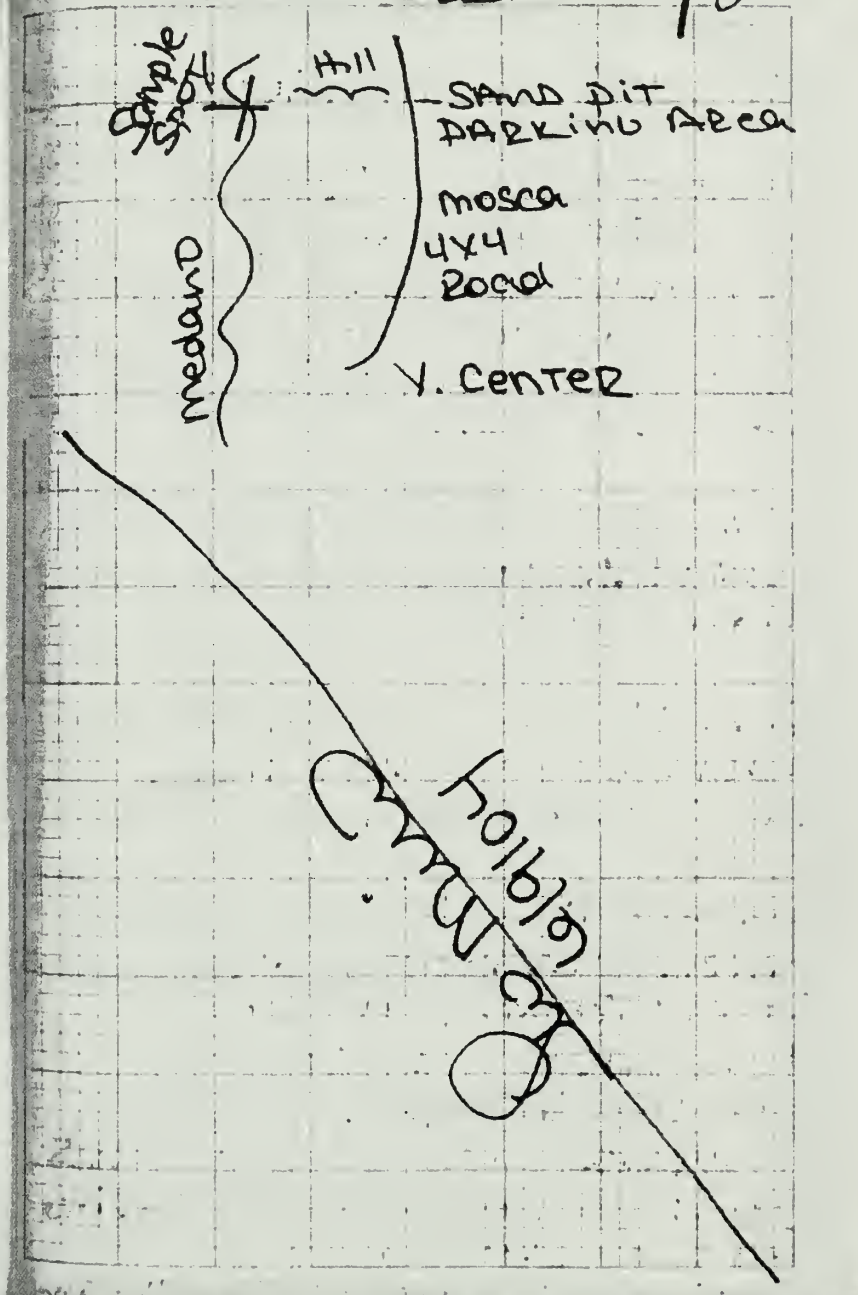
Location: on left hand side, across from sand pit, follow trail head. Sample taken in the highest flow of the water.

Ph: 7.60
Cond: 95.3
Temp: 15.0

AIK: 140 Y.4 = 56 mg/L
Hard: 94 Y.4 = 37.6 mg/L
~~DO: 69 / .8 = 8~~
DO: 69 / .10 = 6.9

Comments: pictures taken upstream and ~~downstream~~. High horse and people area.

6/9/04 LBSA 13/80



6/9/04 GRBA

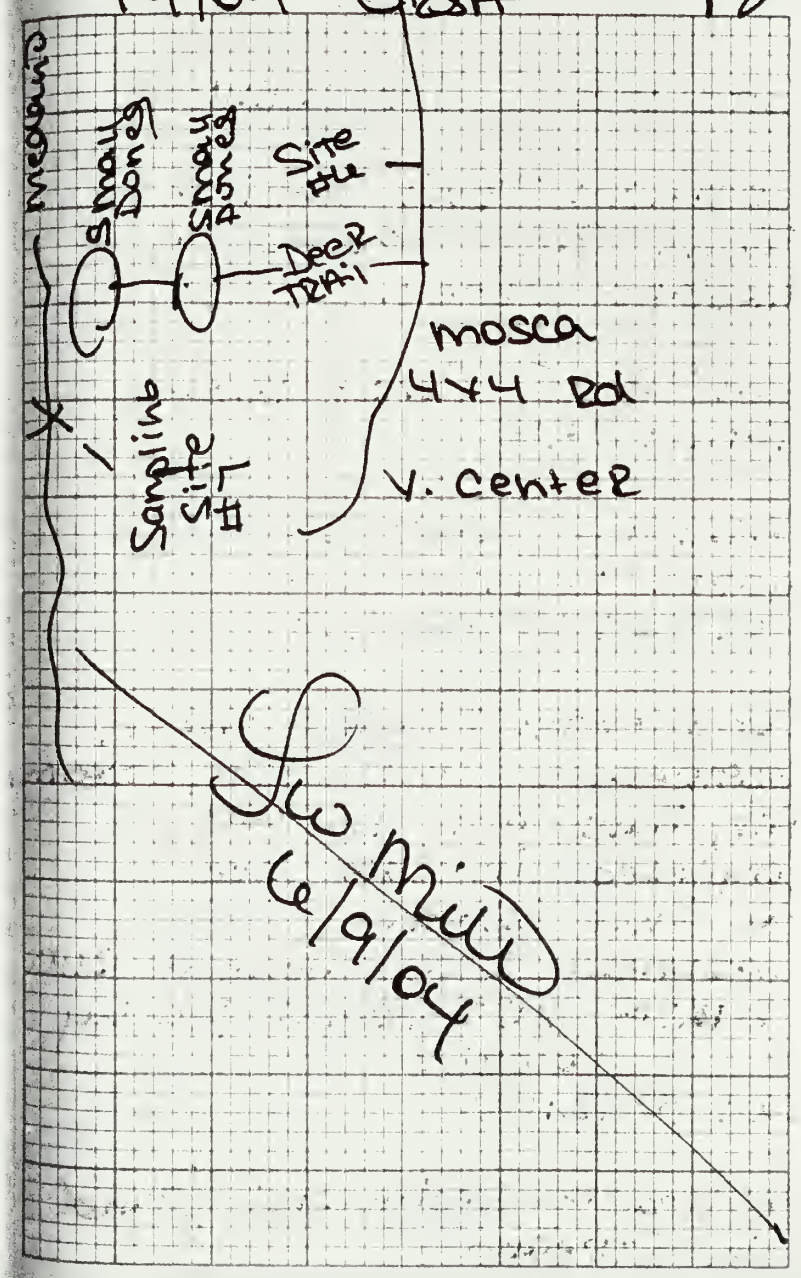
Site #7 Time: 10:15

Location: Deer TRAI on Left, heading towards Dunes. Walk over two Small Dunes, until Get to Creek.

Ph: 7.80
Cond: 59.8 us
Temp: 19.9

ALK: 95 X.4 = 38.0 mg/L
Hard: 102 X.4 = 40.8 mg/L
DO: 77%. 10 = 7.7

Comments: pictures taken upstream and Downstream. Completed ALK, Hard and DO in lab Due to time.
Hardness was Done @ 12:05
ALK: @ 12:20 - Peachy Coloring
DO: @ 12:30 - Heavy Sediment Deposits in Stream



6/9/04 GBSA

Site: #8 Time: 11:10

Location: Trail leading From Camp Ground to Medano Creek.

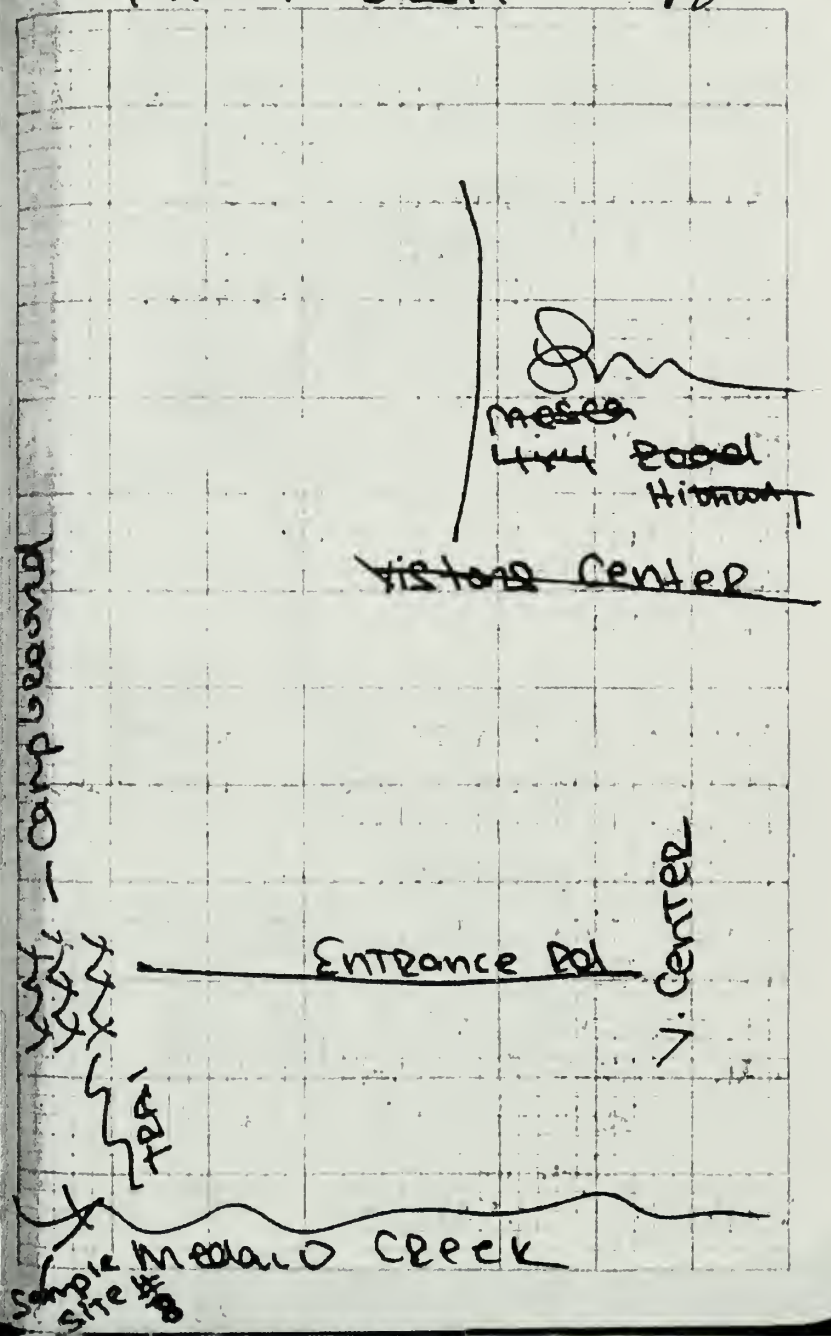
Ph: 7.84 Cond: 93.3 us
Temp: 24.6

Alk: 104 x.4 = 41.6
Hard: 76 x.4 = 30.4
Do: 69 x.10 = 6.9

Comments: Photos taken upstream and Downstream. Alk, Hard and Do was Completed in lab Due to time issues.
Hardness was Done @ 12:10
Alk: @ 12:27 - Bright Peachy Coloring
Do: @ 12:45.

A Heavy Sediment/Sand in Stream

6/9/04 GBSA 13/8



6/9/04 GBSA

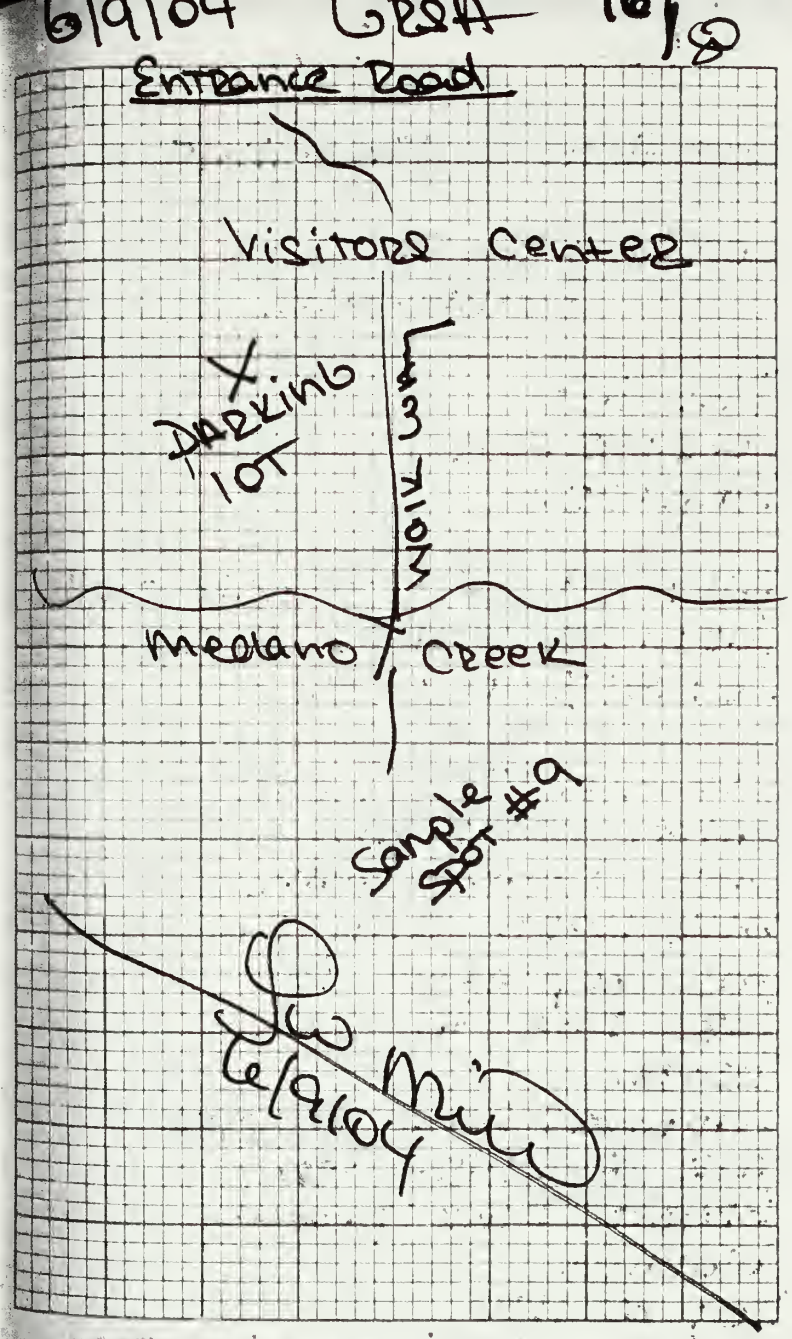
Site #9 Time: 11:30 to 11:35

Location: Boardwalk Crossing By visitors Center.

Ph: 7.80
Cond: 95.6 us
Temp: 25.9

ALK: 101 X.4 = 40.4 mg/L
Hard: 88 X.4 = 35.2 mg/L
DO: 44·1.10 = 4.4

Comments: took photos Downstream and upstream. * Heavy Sediment Deposit in stream. Completed ALK, Hard and DO in lab
Hard: @ 12:14
~~ALK~~ ALK: @ 12:35 very Bright Pink and Peach
DO: @ 12:50.



6/9/04 GBSA

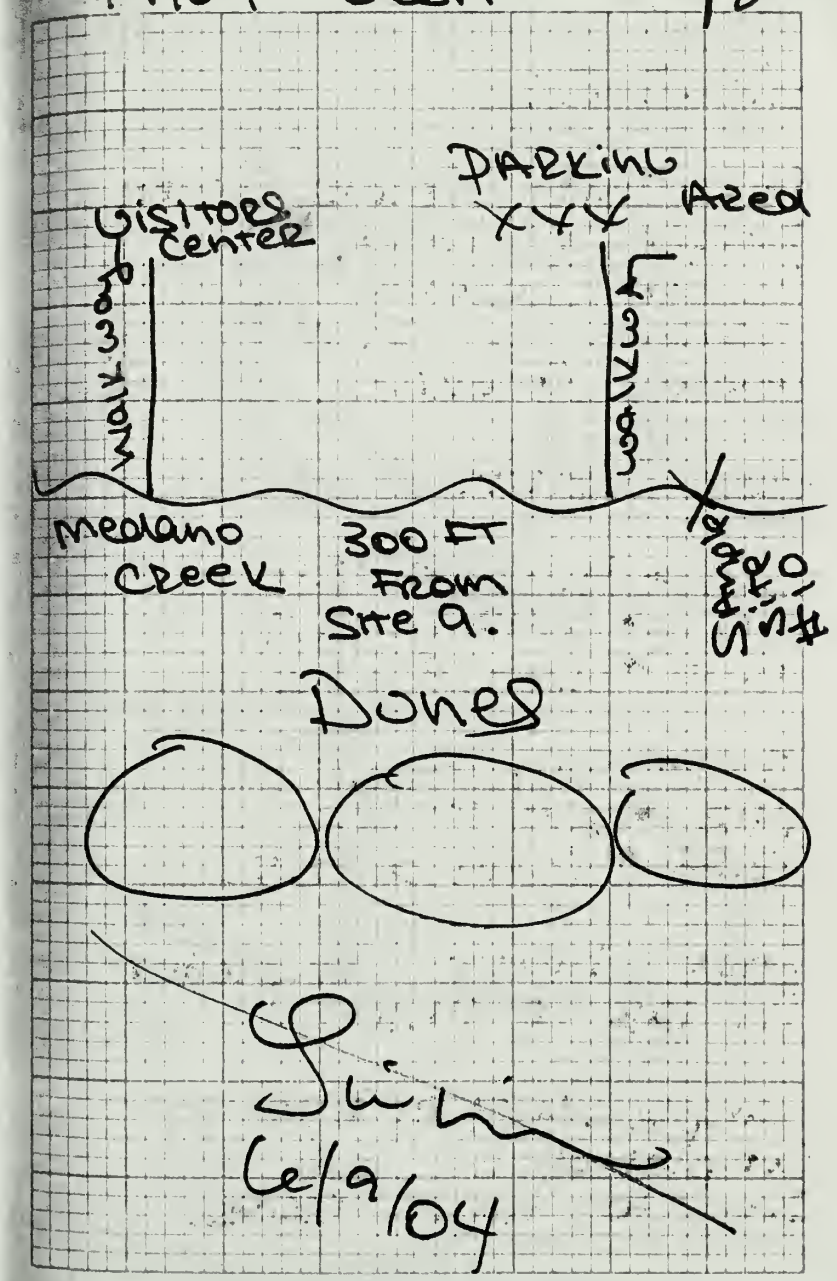
Site # 10 Time: 11:45

Location: 300 ft S. of Boardwalk.

Ph: 7.80
Cond: 95 &us
Temp: 25.6

Alk: 109 X.4 = 43.6 mg/L
Hard: 82 X.4 = 32.8 mg/L
Do: 81% . 10 = 8.1

Comments: Photos taken upstream and downstream. Alk, Hard and Do was completed in lab Due to time issues.
Hardness Done @ 12:16
Alk @ 12:45 - very Bright Pink/Peachy Coloring.
Do: @ 1:00
↳ Heavy Sediments in Stream



6/9/04 GBSA

E.O.D.S:

Alkalinity Colors were Purple in Field, But in lab Colors Changed to Pink / Peachy Coloring.

Post Drift:

4.01 → 4.10 @ 22.6
7.00 → 6.98 @ 21.7
10.00 → 9.89 @ 22.2

747 → 524 @ 22.5
1413 → 1315 @ 22.1
12.88 → 12.44 @ 22.5

Post Drift Completed in lab @ 14:10.

Sample: 4, 7, 8, 9, 10 Completed in lab Due to time issues.

Sample Sites 6-10 Full of Heavy Sediment Deposits.

E.O.D.
@
14:10

6/7/04 GBBA 7

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6/9/04 GBBA 22/80

Time: 14:10-17:00

Weather: Sonny/warm

Purpose: To observe people/animals entering park. To fill out Data sheets with info. such as sex, animals, point of origin, and # of people in vechile.

Team: Lisa Miller

Comments: Started @ 14:10 Due to Am Sampling event.

6/9/04 weather

6/9/04 GRSA

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6/10/04 GRSA 23/80

Time: 08:50 - 13:45

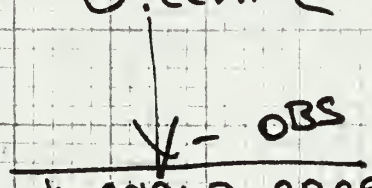
Weather: windy, clear
62°

Purpose: To observe human and animal contact with Meadano Creek, By visitors center.

Team: Lisa Miller.

- Data Sheets filled out for each family unit.
- Comments: not much contact with water due to wind.

End time: 13:45 Doe to Coliform processing with Fred Bunch.



6/10/04 LRSA

6/10/04 Thursday Blank Page

6/11/04 LRSA 24/8

Time: 09:20 - 16:05

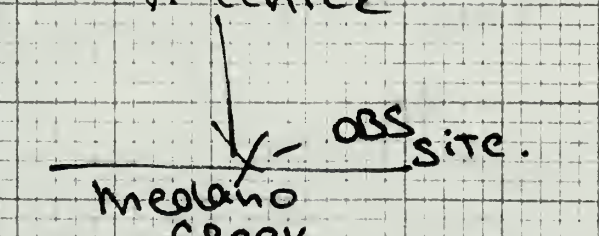
Weather: windy, 65°

Purpose: To observe Human/animal Contact with the Medano Creek. Data Sheets Filled out with for BLT each Family & unit.

Team: Lisa Miller.

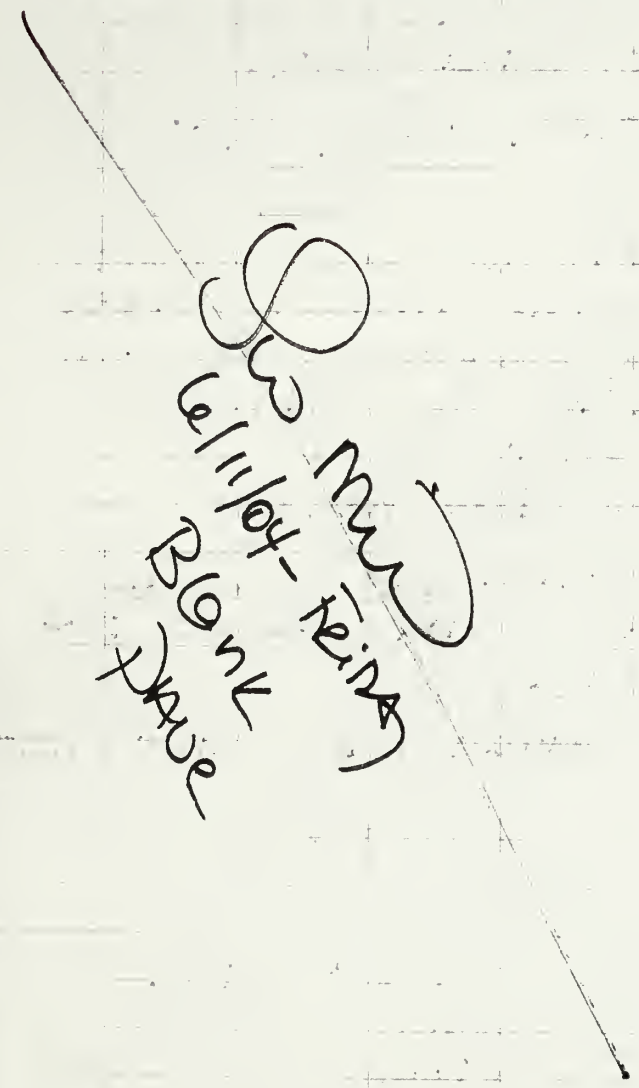
Comments: not alot of Contact with water due to wind.

Took Break from 11:05 - 11:15.



6/11/04

6/11/04 GRSA



6/12/04 GRSA 25/80

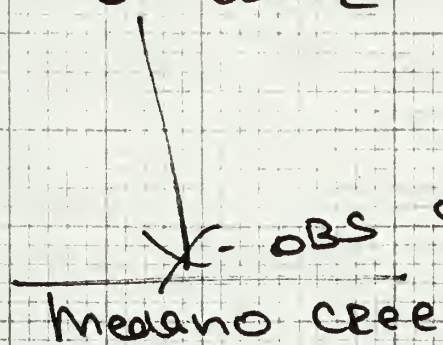
Time: 09:30-16:30

Weather: windy, clear
65°

Purpose: To observe human/animal contact with Medano Creek. Data sheets filed out for each family unit.

Team: Lisa Miller.

Comments: High wind. Handle no contact with water.

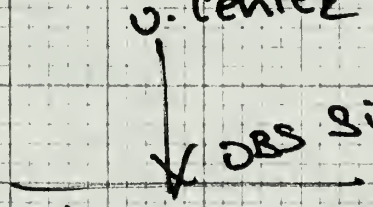


6/12/04 GRSA

No mud
6/12/04-
SAT.
BLANK PAGE

6/13/04 GRSA 26/80

Time: 09:00-12:00
Weather: windy, clear
65°
Purpose: to observe
contact with Medano
Creek, human and animal.
Data sheets were filled
out for each family unit.
Team: Lisa Miller



No mud
6/13/04
Sunday
LAST DAY GRSA

Point of Origin – Summary Statistics Generated from 6/5/04 through 6/12/04

Total Summary

In States:

Adult		Child			
Male	Female	Male	Female	Dogs	Horses
1169	1076	333	286	73	12

Foreign:

Adult		Child	
Male	Female	Male	Female
28	21	2	0

Point of Origin Survey for GRSA
June of 2004

5-Jun-04	Adults Male	Adults Female	Dogs	Children Male	Children Female
CO	495	445	44	153	122
NM	18	17	4	5	1
TX	18	17	0	7	4
MN	5	6	0	1	0
Iowa	6	5	0	0	0
LA	2	2	0	0	0
NH	1	1	0	0	0
GA	2	2	0	0	0
NE	1	1	0	1	0
PA	1	1	0	0	0
KY	1	1	0	0	0
UT	3	2	0	0	0
WI	6	5	0	3	1
MO	8	10	0	2	1
IL	10	6	2	2	1
OK	5	5	0	1	0
KS	8	10	2	1	0
FL	4	4	1	0	0
AZ	4	1	0	0	0
WY	2	2	0	1	0
SC	1	1	0	0	0
Indiana	2	2	0	0	0
NY	1	1	0	1	0
NC	2	2	0	0	0
CA	2	3	0	0	0
OH	1	1	0	0	0
ARK	3	3	0	1	1
MICH	2	2	0	1	1
ID	10	10	0	1	1
Vermont	1	1			
Grand Total:	625	569	53	181	133

Foreign:

France	2	0	0	0	0
Germany	7	6	0	1	0

London	1				
England	3	2	0	1	0
Check Republic	1	1	0	0	0
Nepal	2	1	0	0	0
Grand Total	**16**	**10**	**0**	**2**	**0**

4-Horses

Observation Completed at the Entrance Booth of GRSA:
Saturday, June 5, 2004 from 9:00 to 13:30

Point of Origin Survey for GRSA 6/04

	Adults			Children	
6-Jun-04	Male	Female	Dogs	Male	Female
CO	141	151	6	35	40
NM	8	8	2	3	1
TX	22	11	2	3	3
MN	3	2			
NE	1	1	0	1	1
MO	0	2	0	0	0
IL	1	1	0	0	0
KS	2	2	0	0	1
NC	1	1			
CA	5	5	0	1	1
MICH	2	2	0	0	0
ID	3	2			
MD	1	1	0	0	2
Canda	1	0	0	1	1
TN	2	2	0	0	0
MA	1	1	1	0	0
Grand Total:	**194**	**192**	**11**	**44**	**50**

Foreign:

France					
Germany	1	1	0	0	0
London	1	1	0	0	0
Austria	2	2			
Grand Total	**4**	**4**	**0**	**0**	**0**

8 Horses
Sunday, June 6, 2004 from 9:30 to 12:00

Point of Origin Survey for GRSA

June of 2004

7-Jun-04	Adults			Children	
	Male	Female	Dogs	Male	Female
CO	141	136	8	60	59
NM	9	3	0	0	3
TX	26	20	0	14	17
MN	1	2	0	1	1
Iowa	1	1	0	0	0
LA	0	1	0	0	0
NH	1	1	0	0	0
NE	1	1	0	0	0
PA	0	1	0	0	0
KY	4	0	0	0	0
WI	1	1	0	0	0
MO	3	5	0	2	1
IL	5	5	0	5	3
OK	1	4	0	1	0
KS	9	5	0	2	0
FL	8	3	0	0	0
AZ	5	3	0	1	3
Indiana	1	1	0	0	0
NY	3	0	0	0	0
NC	2	3	0	0	0
CA	3	3	0	0	0
OH	14	11	0	0	0
ARK	1	1	0	1	0
MICH	2	1	0	0	0
Vermont	2	2	0	0	1
Mach	3	2	0	0	0
Virginia	2	4	0	0	0
TN	3	3	0	2	0
NJ	0	1	0	0	2
Penns.	1	0	0	0	0
WA	0	1	0	0	0
OR	2	2	0	0	0
Maryland	1	3	0	0	0
Grand Total:	256	230	8	89	90

Foreign:

France	1	1			
Germany	3	2	0	0	0
Ireland	1	1	0	0	0
Poland	1	1	0	0	0
Norway	0	2	0	0	0
Check Republic	2	0	0	0	0
Grand Total	8	7	0	0	0

Observation Completed at the Entrance Booth of GRSA:
Monday, June 7, 2004 from 9:45 to 17:00

Point of Origin Survey for GRSA

June of 2004

	Adults			Children	
9-Jun-04	Male	Female	Dogs	Male	Female
CO	74	73	1	13	6
NM	1	1	0	0	0
GA	0	2	0	0	0
NE	1	1	0	0	0
KY	1	1	0	0	0
WI	1	0	0	2	0
IL	3	0	0	0	0
KS	2	0	0	3	2
FL	2	1	0	0	0
NC	1	1	0	0	0
CA	5	2	0	1	1
OH	1	0	0	0	0
MISS	1	2	0	0	4
TN	1	1	0	0	0
Grand Total:	94	85	1	19	13

Foreign:

Grand Total	0	0	0	0	0

Observation Completed at the Entrance Booth of GRSA:
Wednesday, June 9, 2004 from 14:10 to 17:00

Point of Origin Survey			
3	AL	0.16%	
4	AK	0.22%	
20	AZ	1.09%	12
17	AR	0.93%	14
31	CA	1.69%	8
974	CO	53.17%	1
3	CT	0.16%	
1	DE	0.05%	
42	FL	2.29%	6
11	GA	0.60%	18
0	HI	0.00%	
11	ID	0.60%	18
16	IL	0.87%	15
14	IN	0.76%	17
22	IA	1.20%	10
40	KS	2.18%	7
4	KY	0.22%	
6	LA	0.33%	
2	ME	0.11%	
11	MD	0.60%	18
6	MA	0.33%	
4	MI	0.22%	
18	MN	0.98%	13
3	MS	0.16%	
49	MO	2.67%	5
3	MT	0.16%	
5	NE	0.27%	
3	NV	0.16%	
2	NH	0.11%	
7	NJ	0.38%	
78	NM	4.26%	4
15	NY	0.82%	16
10	NC	0.55%	19
1	ND	0.05%	
25	OH	1.36%	9
21	OK	1.15%	11
7	OR	0.38%	
8	PA	0.44%	21
0	RI	0.00%	
4	SC	0.22%	
2	SD	0.11%	
10	TN	0.55%	19
153	TX	8.35%	2
8	UT	0.44%	21
3	VT	0.16%	
9	VA	0.49%	20
4	WA	0.22%	

Appendix C

Correspondence

C.1 Meeting Notes

Listed below are the notes held from each meeting in regards to the Great Sand Dunes.

Sand Dunes
Meeting 5-19-04

Attendees:
Karmen King, Mike Thompson, Lisa Miller

Items discussed:

1. Visit park during sampling event.

Items needed before next meeting:

*Review:
1, ATSDR Reports
2. Toxicology reports by EPA
3. Public Health Service Reports
4. CDC web page

*Complete data sheet:
1, Age
2. Sex
3. Body weight
4. Contact with water
5. Ingesting only

*Information from Fred Bunch
1. Q-Permits to camp in upper Medano (Source)
2. (Observe tents to see how many people, sex and weight.
3. Indiana Grove (Back Country Site, tested in 1998, in between Medano and Sand Pit). Location is not on sampling map. Other information???
4, Status from park: how many people visit daily and what are the fees paid.
5. Sit at booth and observe people.

*Karmen will contact Fred Bunch for the following information:
1. Coliform study during visit time.
2. Holding a meeting on the 4th of June in the afternoon.

*Next meeting time: June 2nd Cloud City Coffee House @ 6:30 am.

*Items to get from visit:
Flow
Lap top
Data

Sand Dunes
Meeting 6-2-04
6:30-7:15 Cloud City Coffee House

Attendees:
Karmen King
Mike Thompson
Lisa Miller

Items discussed:

1. System for observing:
    A. Four hour blocks (9-1 and 1-5)
    B. One person rotates around to view all traffic entering.
    C. Have one full day on the 5th
    D. Two full days during the week
    E. Spilt out shift, 9-1 at the visitor's center, 1-5 at the trail crossing.
    F. Next day change up. 9-1 at trails crossing, 1-5 at visitors center.
    G. Have one full day on the 12th
    H. Have a half day ending at 12:00 on the 13th (finish with high packed area.

2. Data base research to work on during the week:
    A. Tetons: Review baseline study
    B. ATSDR for Lead and Fluoride
    C. Toxicity report for Fluoride
    D. Gather statistics on visitors for the Dunes.

Items needed before visit:

1. Toxicity reports from EPA on coliform
2. ATSDR Reports (search for coliform)

Questions for Fred Bunch:

On following page

Items to get from visit:

1. *Flow* *Only gather these items if study of coliform is being conducted.*
2. *Ph reading*
3. *Trititan*

Next meeting time: June 4th at the Great Sand Dunes with Fred Bunch.

Phone call 6-2-04 at 5:00 with Fred Bunch:

Is it possible to sit in front of the park and observe visitors?

-Yes, can walk around park and look at licenses plates.
-Can use booth in front of the park to gather information.
-GRSA has a point of origin data-can get copies.
-GRSA has a study on person per vehicle (Tom Moren is the contact)

What are the statistics on visitor use (how many people visit daily and where are they from)?

-GRSA has statistics from two years ago. University of Idaho completed study.
-Study shows the age and sex-he will provide copies.

Will there be a coliform sampling event during the 4-13 visit?

-Yes, One sampling event took place today, but one will occur during my visit.

What permits are required to camp in upper Medano creek?

-No permits required to camp.
-GRSA has monitored the impacts on those upper camping spots and took photos.
-Katie a Technician has the photos and reports. She will not be there on Friday but on Monday.

Are the ages and sex listed on them?
-No, but we can travel with the patrol ranger and observe the campers.

Meeting Notes
June 4, 2004 @ 14:30

Attendees:

Fred Bunch
Steve Chaney
Lisa Miller
Karmen King
Mike Thompson

Items discussed:

1. Field observations should be completed on Thursday and Friday.
2. Monday and Tuesday are slow days in park.
3. Kacey Hagaman is the water technician, in charge of treating all water.

Recommendations by Fred Bunch:

1. Keep track of pets that enter the park
2. Check out back country sites, such as Indiana Grove, and Castle Creek.
3. Accompany Katie Haganan the technician on Coliform sampling.
4. Get a point of origin survey with Tom Morin (Entrance Booth Manager).
5. Check with Jim Flynn from the Oasis Market on when he provides horse tours.

Basic Information:

1. Showers have been placed in the park with in the last couple of years.
2. No records have indicated individuals getting sick from water.

Next meeting time:

Monday, June 7, 2004

Questions for Fred Bunch
On June 4, 2004

1. What is the potable supply?

It is above park. There is one well for housing.

2. Is the water treated?

   A. Treated through aquifer.
   B. Four main wells.
   C. Above and low campground
   D. Water in picnic area and housing.

3. Is there a septic system? And where?

   A. Yes, in housing and dunes lot.
   B. Leach fields several

4. Are there any infrastructure water details?

   A. Domestic from water, chlorinated.

   B. What is the use of the potable water? Do the visitors use it?

   One well above campground

   Visitors use the campground use.

Meeting Notes
June 5, 2004 @ 9:00

Attendees:

Lisa Miller
Fred Bunch
Katie Hagaman

Items Discussed:

1. Conduct Colfiorm sampling event on Tuesday, June 6th at 1:00 with Katie.
2. In the past sites one and four have been low in Coliform.
3. The June 3rd sampling event was the first event of the year.
4. There are bathrooms at Summit and Indiana Grove.

Questions for Fred Bunch
On June 4, 2004

1. What is the potable supply?

It is above park. There is one well for housing.

2. Is the water treated?

   A. Treated through aquifer.
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   C. Above and low campground
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3. Is there a septic system? And where?

   A. Yes, in housing and dunes lot.
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4. Are there any infrastructure water details?

   A. Domestic from water, chlorinated.

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Meeting Notes
June 5, 2004 @ 9:00

Attendees:

Lisa Miller
Fred Bunch
Katie Hagaman

Items Discussed:

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2. In the past sites one and four have been low in Coliform.
3. The June 3rd sampling event was the first event of the year.
4. There are bathrooms at Summit and Indiana Grove.

Appendix D

Pictures taken of activity in the Medano Creek by Boardwalk Crossing

Great Sand Dunes National Monument Entrance Booth

Incoming traffic to GRSA

Family Unit playing in Medano Creek

Photo looking towards sample site 10

Photo taken across from Boardwalk Crossing into Medano Creek

Group of Children playing in Medano Creek

Mother with Baby

Group of people playing in Medano Creek look towards sample site 10

Group of people playing in Medano Creek look towards sample site 9

Lisa Miller with CMC observing visitors of GRSA by Boardwalk Crossing